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DEPARTMENT OF DEFENSE HUMAN FACTORS ENGINEERING TECHNICAL ADVISORY GROUP

MINUTES OF THE FIFTEENTH MEETING SAN DIEGO, CALIFORNIA

5 - 7 NOVEMBER 1985

HOSTED BY:
NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA

CHAIR:
MR. CYRUS D. CRITES
TEST-ENAH
EDWARDS AFB, CALIFORNIA

DRAFT

MINUTES OF THE FIFTEENTH MEETING OF THE
DEPARTMENT OF DEFENSE
HUMAN FACTORS ENGINEERING
TECHNICAL ADVISORY GROUP

SAN DIEGO, CALIFORNIA
5-7 November 1985

The fifteenth meeting of the Department of Defense Human Factors Engineering Technical Advisory Group (TAG) was held in San Diego, California from 5-7 November 1985. During the meeting, which was hosted by the Navy Personnel Research and Development Center, the Controls and Displays; Human Factors Engineering Guide to Systems and Equipment Development; Human Factors in Logistics; Human Factors Test and Evaluation; Manned System Modeling; Professional Education, Training, and Career Development; Technical Society/Industry Committee; Tri-Service Human Factors Standardization Steering Committee; Tri-Service Workload Coordinating Committee; User-Computer Interaction; and Voice-Interactive Systems subgroups met in scheduled concurrent sessions.

The agenda (Attachment A) for the fifteenth TAG meeting was structured so that administrative matters were interspersed with technical discussions. For ease in reading the Minutes, the administrative and professional/technical discussions have been resequenced as follows:

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1. EXECUTIVE SUMMARY

The fifteenth meeting of the DOD HFE TAG, hosted by the Navy Personnel Research and Development Center, was held in San Diego, California from 5-7 November 1985. Meeting in conjunction with the TAG were the following subgroups: Controls and Displays; Human Factors Engineering Guide to Systems and Equipment Development; Human Factors in Logistics; Human Factors Test and Evaluation; Manned System Modeling; Professional Education, Training and Career Development; Technical Society/Industry Committee; Tri-Service Human Factors Standardization Steering Committee; Tri-Service Workload Coordinating Committee; User-Computer Interaction; and Voice-Interactive Systems.

During the three-day meeting, a tutorial on the selection of human performance measurements was presented, implementation efforts for the Army's manpower, personnel and training program were discussed and an analysis center for crew system ergonomics information was described.

Other briefings related to the impact of spatial disorientation on aircraft attitude/control; HUDs; and artificial intelligence and expert systems. An overview of the human factors projects at NPRDC was presented and, on the final day of the meeting, attendees toured the NPRDC facilities.

Administrative Summary

- The Minutes of the Fourteenth meeting are to be distributed as soon as they are released from the issuing printshop.
- The Air Force will chair meeting 16 with Mr. Cyrus Crites [Edwards Air Force Base] serving as the current DOD HFE TAG Chair.
- The Army will chair meetings 17 and 18. Dr. Michael Strub [ARI Field Unit/Bliss] will serve as the Army Chair.
- NASA will host the sixteenth meeting to be held at the Kennedy Space Center, Florida in early May 1986.

Committee and SubTAG Summary

Reports were presented by the chairs or representatives of the following subgroups: Controls and Displays; Human Factors Engineering Guide to Systems and Equipment Development; Human Factors in Logistics; Human Factors Test and Evaluation; Manned System Modeling; Professional Education, Training, and Career Development; Sustained/Continuous Operations; Technical Society/ Industry Committee; Tri-Service Human Factors Standardization Steering Committee; Tri-Service Workload Coordinating Committee; User-Computer Interaction; and Voice-Interactive Systems.

Announcements

The following subgroups have selected new chairs or new chairs select:

- Human Factors Test and Evaluation -- Dr. James C. Geddie, USA Human Engineering Laboratory Field Unit/Hood;
- Technical Society/Industry Committee -- Dr. Mark M. Brauer, AIIE Representative, Lockheed-California Company; and
- Voice-Interactive Systems -- Ms. Elaine Schiller, Naval Ocean Systems Center.

2. INTRODUCTION AND WELCOMING REMARKS

2.1 Call to Order -- Mr. Cyrus D. Crites, TEST-ENAH, Edwards Air Force Base, California

Mr. Crites, DOD HFE TAG Chair, welcomed attendees to the fifteenth meeting of the TAG and expressed his appreciation to the Navy Personnel Research and Development Center (NPRDC) for hosting the meeting. Presentors were reminded to submit hardcopies of their presentations and visual materials to the TAG Coordinator for inclusion in the Minutes of the meeting.

Mr. Crites introduced Commander John E. Kohler of NPRDC. Commander Kohler, a graduate of the United States Naval Academy, also holds a master's degree in business administration and served as the Commanding Officer of NPRDC until October 1985. Commander Kohler's personal awards include the Air Medal and the Navy Achievement Medal.

2.2 Navy Personnel Research and Development Center Welcome -- Commander John E. Kohler

On behalf of NPRDC, Commander Kohler welcomed TAG attendees to San Diego and encouraged them to utilize the opportunity to tour NPRDC's human factors facilities. He noted the vital role the human factors community plays in system design and recommended that TAG members increase their awareness of maintainability issues.

3. ADMINISTRATIVE BUSINESS

3.1 Minutes of the Fourteenth Meeting

The draft Minutes of the Fourteenth Meeting have not been released from the issuing printshop. These Minutes will be distributed as soon as released. Amendments to these Minutes should be sent to the TAG Chair, Mr. Cyrus Crites, by 15 January 1986, for inclusion in the draft Minutes of the Fifteenth Meeting.

[As of 15 January, the Minutes of the Fourteenth meeting had not been released from the issuing printshop.]

3.2 Service Caucus Reports

Army Service Representative, Mr. Clarence A. Fry (USA HEL), reported that the group discussed the Army's MANPRINT program and whether or not the manpower, training and personnel communities have appropriate/sufficient tools to address the issues raised by MANPRINT; and concluded that, at present, the answer is negative. The group also reviewed the OUSDR&E letter regarding cockpit automation technology; and in other business, selected a representative to interface with the Crew Station Ergonomics Information Analysis Center project. Dr. Michael H. Strub is the TAG Chair Select and the group will select a new TAG Service Representative at its May 1986 meeting.

Navy Service Representative, LCDR Thomas M. Mitchell (PMTC), announced that the group had formalized the selection of Dr. John O'Hare (ONR) to fill the Navy seat vacated by Mr. Paul M. Linton and LCDR Mitchell to fill the Service Representative position vacated by CDR Larry M. Dean. LCDR Mitchell noted that the Navy had petitioned the Operating Board to have the Service Representative position extend until May 1988, so that the Navy would not have to hold another election at the May 1986 meeting. Dr. O'Hare's term will expire when the Navy elects a TAG Chair Select.

Air Force Representative, Dr. Richard J. Schiffler (ASD/ENECH), reported that the group had discussed a number of Service issues. In other business, the group recommended better Air Force coverage of the various subgroup meetings: Dr. Schiffler will implement this recommendation prior to the May 1986 TAG meeting. A new Service Representative will be selected at the May 1986 meeting.

3.3 Operating Board Report

Mr. Crites noted that the TAG had received a copy of a memorandum sent by Donald I. Carter, Acting Deputy Under Secretary of Defense (Research and Advanced Technology), to the Assistant Secretaries of the Army, Navy, and Air Force. The memorandum cites the productivity of the TAG as a vehicle for the exchange of technical data and coordination of HFE research among DOD laboratories, NASA and the FAA. [See Attachment E.1.]

Mr. Crites reported that the TAG had received a letter from Captain Paul R. Chatelier (Office of the Under Secretary of Defense R&AT) requesting assistance in obtaining background information on human factors research impacting Cockpit Automation Technology. The Operating Board discussed methods of obtaining the desired information and determined that the most efficacious approach would be to utilize 1498s (work unit R&D effort summaries), cutting across service projects by the use of

keywords. Mr. James Hartzell (NASA-Ames) will provide the 1498 data to Mr. Crites who will distribute pertinent information to selected subgroup chairs for their inputs. A summarization of the findings is to be sent to Captain Chatelier in early January 1986. [See Attachment E.2.]

A letter of appreciation from Dr. Joseph A. Birt has been received by the Operating Board. For a copy of this letter, see Attachment E.3.

NASA-Kennedy Space Center has offered to host the sixteenth meeting of the TAG. The meeting will be scheduled for early May 1986.

4. COMMITTEE AND SUBTAG REPORTS

4.1 Committee Reports

4.1.1 Human Factors Engineering Guide to Systems and Equipment Development (Dr. K. Boff) -- Mr. Steve A. Heckart, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio

View Graphs -- Attachment O

Mr. Heckart noted that this effort had been ongoing for a number of years; and that the former Chair, Dr. Joseph A. Birt, had requested and received approval from the TAG Operating Board to solicit recommendations regarding a potential HEGED update from the National Research Council (NRC). NRC responded to the Committee's request and recommended that technology considerations suggested that an electronic format would be more suitable than a printed handbook format. NRC also recommended that the Committee consider the appointment of an editorial board to oversee the effort. NRC informed the Committee that although it was unable to undertake or supervise a HEGED revision, it would be prepared to make inputs. According to Mr. Heckart, Dr. Kenneth Boff will provide a formal response to NRC.

In light of the recommendations made by the NRC, the group discussed its status and concluded that serious consideration should be given to disbanding the Committee since its task had been completed, i.e. that of investigating the feasibility of an update of the hardcopy Human Engineering Guide to Equipment Design. The Committee agreed, however, that the need still exists for some organized method of determining the location of human engineering data and intends to discuss focusing on accessible databases and retrieval systems.

Mr. Heckart presented a brief overview of Dr. Boff's Integrated Perceptual Information for Designers (IPID) effort. Products expected from this effort include a handbook, a data compendium, and an automated database management system. The

Handbook of Perception and Human Performance is scheduled for publication by John Wiley & Sons, New York, in March-April 1986. This two-volume work has 45 chapters and over 3000 pages. The engineering data compendium prototype has been developed and distributed. The final version is expected to contain over 1200 entries in three volumes and should be completed in the spring of 1986. The Designer's Associate characterizes optimal DOD design processes, defines the tools and databases needed and configures a workstation concept. The Designer's Associate serves as an automated data management for designers by encoding, in this case, IPID human performance data and biotechnical and systems design data. It also functions as a "problem-solving" partner by helping to formulate relevant questions, by tailoring questions to the available information resources and by devising retrieval strategies.

In closing, Mr. Heckart announced that a short course on human perception and performance is scheduled for 7-11 April 1986 in Dayton, Ohio. For additional information, please contact Dr. Boff at (513) 255-7596/7602; AV 785-7596/7602.

4.1.2 Professional Education, Training, and Career Development -- Mr. D. Todd Jones, US Coast Guard, Washington, DC

According to Mr. Jones, funding is the major impediment to the subgroup's continuation of its efforts to study what constitutes a human factors engineering professional. To date, three workshops utilizing (Dr. Sidney) Fine's Functional Job Analysis have been held:

Workshop I	-	HFE Specialists in RDT&E in Military Systems,
Workshop II	-	HFE Specialists in Consumer/Commercial Systems, and
Workshop III	-	HFE Specialists in Forensics/Safety.

Mr. Jones will continue to explore funding alternatives and will report on his efforts in this regard at the next subgroup meeting.

4.1.3 Technical Society/Industry Committee -- Dr. Frederick A. Muckler, American Psychological Association/Division 21 Representative, Essex Corporation, San Diego, California

Dr. Muckler noted that the Committee had held two meetings with eight organizations being represented. As is the TS/I custom, each representative supports those SubTAGs in which his skills and interests can be utilized. In attendance were:

. Dr. Mark M. Brauer, American Institute of Industrial Engineers -- User-Computer Interaction

. Dr. Thomas M. Cook, Association of Artificial Intelligence (P) -- User-Computer Interaction

. Dr. Richard F. Gabriel, System Safety Society -- Controls and Displays

. Mr. Wolf J. Hebenstreit, Electronic Industries Association and the National Security Industrial Association -- Tri-Service Human Factors Standardization Steering Committee

. Dr. Norman E. Lane, Human Factors Society -- Manned System Modeling

. Mr. Maurice A. Larue, Jr., Aerospace Industries Association -- Tri-Service Human Factors Standardization Steering Committee

. Dr. Frederick A. Muckler, American Psychological Association/Division 21 -- Human Factors Test and Evaluation.

Dr. Muckler reported that the Committee is attempting to respond to the request for data on cockpit automation technology and he reminded TAG attendees that the Committee is available to make inputs or to provide data in a variety of areas, should the need be called to its attention.

In other business, Dr. Mark M. Brauer has been selected as the new TS/I Chair.

4.2 SubTAG Reports

4.2.1 Controls and Displays -- Mr. Jeffrey D. Grossman, Navy Personnel Research and Development Center, San Diego, California

See Attachment F.1 for the Minutes of the Meeting. See Attachments F.2 and F.3 for related materials.

4.2.2 Human Factors in Logistics -- Mr. Dale Mahar, Pacific Missile Test Center, Point Mugu, California

See Attachment G for the Minutes, Attendee List and briefing materials submitted by Mr. Mahar.

4.2.3 Human Factors Test and Evaluation (CDR W. Moroney) -- Mr. Keith S. Karn, Naval Air Test Center, Patuxent River, Maryland

See Attachment H for the Minutes, Attendee List and related materials submitted by Mr. Karn.

4.2.4 Manned System Modeling -- Mr. E. James Hartzell, NASA-Ames Research Center, Moffett Field, California

Charter and View Graphs -- Attachment I

Mr. Hartzell reported that the SubTAG had discussed a variety of models and modeling issues. However, due to time constraints, it was not possible to discuss the various projects in great depth. The subgroup hopes to remedy the situation by participating in a proposed modeling workshop to be held in the summer of 1986 at Wright-Patterson Air Force Base. [For an update on workshop plans, please contact Mr. Hartzell or Mr. Robert Bachert at (513) 255-2423/AV 785-2423.]

Brief overviews of ongoing projects were presented by:

. Mr. Joe M. Jones (AD/ENP; Eglin Air Force Base) discussed his efforts on modeling of voice sounds. Although this effort is not a typical voice stress analysis model, it provides some interesting information with regards to workload and stress.

. Dr. Charles C. Jorgensen (Oak Ridge National Laboratory) discussed artificial intelligence and robotic projects at Oak Ridge and noted that Oak Ridge is also involved in the modeling of the outer layers of retinal function.

. Dr. Norman Warner (Naval Air Development Center) gave a review of HOS and its applications to the chemical defense area.

. Mr. Michael D. McNeese (Armstrong Aeromedical Research Laboratory) presented a thorough report on ongoing modeling efforts at AAMRL and gave a general overview of the Rapid Intelligent Prototyping Laboratory (RIPL) and the C^3 Operator Performance Engineering (COPE) program.

. Captain Robert K. McCoy (AFOTEC/Kirtland Air Force Base) solicited the aid of the SubTAG for inputs regarding his attempt to use a networking model approach at the Consolidated Space Operations Center. Mr. Hartzell noted that the group discussed the possible interaction between Captain McCoy's approach and requirements and efforts discussed by Mr. McNeese.

Mr. Hartzell reported that Dr. Edwin R. Smootz (ARI FU/Hood) had directed the SubTAG's attention to the need for improved field-derived data since these data are being utilized as inputs to modeling. Dr. Norman E. Lane (Human Factors Society Representative) reminded the group to be alert to changes in goals, noting that if the model is not sensitive to goal changes, it will lack validity.

Mr. Hartzell announced that the 25 attendees had approved the Manned System Modeling Charter.

4.2.5 Sustained/Continuous Operations -- Lieutenant Colonel Gerald P. Krueger, Walter Reed Army Institute of Research, Washington, DC

See Attachment J for the report submitted by Lieutenant Colonel Krueger.

4.2.6 Tri-Service Human Factors Standardization Steering Committee (HFSSC) -- Mr. Gerald Chaikin, US Army Missile Command, Redstone Arsenal, Alabama

View Graphs -- Attachment K.1
Minutes of 7 May 1985 -- Attachment K.2

Mr. Chaikin presented a brief overview of the Committee's activities, noting that the preparation of the DOD Human Factors Standardization Program (HFAC) Plan is the subgroup's primary reason for existence. The HFAC Plan provides the basis for efforts in the human factors standardization area for a five-year period. Inputs to the document are essentially established by the individuals serving on HFSSC. The document is revised every two years and the most recent revision (Revision 4, dated 21 August 1985), was accepted and signed as submitted.

Mr. Chaikin presented status reports on the projects listed below.

- HFAC-0009 (Manpower, Personnel and Training Data Requirements, EPS). John L. Miles, Jr. (ARI) and Stephen C. Merriman (DTDAC), along with Air Force participation have completed the final report of this effort. The report contains specific recommendations on personnel and training data items, including: the review of 99 data items; the suggested abolition of 41 data items; and suggestions for future efforts. This report will be circulated in November 1985 for formal review by the affected agencies.

- HFAC-0016 (MIL-STD-1294A). This effort on Acoustical Noise Limits in Helicopters has been completed; additional data items were included in the document.

- HFAC-0024 (DOD-HDBK-761). This completed document is a reissuance of the 1983 (D.E.) Hendricks et al. Human Engineering Guidelines for Management Information Systems in DOD Handbook format. The UCI SubTAG will serve as the agent for future updates of this document.

- HFAC-0027 (Human Engineering Procedures Guide). Boeing is under contract to prepare this document in DOD Handbook format. The document is a condensation and update of previous individual Service Guides on the imposition and implementation of MIL-H-46855 data items. [For the status of other HFSSC projects, see K.1-2.]

In closing, Mr. Chaikin reported that the SubTAG discussed a major NASA human engineering effort. The 18-month Man-System Integration Standards (MSIS) project began in July 1985

and is intended to develop a set of man-system integration standards, requirements, and guidelines for human presence in space. MSISs will be based on existing standards, requirements, and guidelines in so far as possible. Discrepancies and voids in existing data are to be identified and resolved, utilizing the expertise of both government and industry personnel. Products of this effort are expected to include:

1) a volume containing criteria, background, data rationale and other useful information for designers of zero gravity applications;

2) a Standard, similar in concept to 1472;

3) a pocket edition of the handbook, similar to the Human Engineering Design Data Digest; and

4) a computerized relational database.

The HFSSC has formally requested that the Program Manager for this effort be invited to present at the next TAG plenary session.

4.2.7 Tri-Service Workload Coordinating Committee -- Ms. Heidi M. Fiedler, Naval Underwater Systems Center, Newport, Rhode Island

See Attachment L for the Report and visual materials submitted by Ms. Fiedler.

4.2.8 User Computer-Interaction (Mr. L. Peterson) -- Dr. John J. O'Hare, Office of Naval Research, Washington, DC

View Graphs -- Attachments M.1 through M.7

Dr. O'Hare reported that the SubTAG had agreed to be the agent for the updating of DOD-HDBK-761A and for the preparation of a stand-alone version of section 5.15 of MIL-STD-1472C. Schedules for these efforts will be furnished to the Tri-Service Standardization Steering Committee.

In other action, Dr. O'Hare noted that an on-line database of annotated documents on user-computer interfaces has been established. Access to a demonstration of this database, contracted to Battelle Columbus Laboratories, can be obtained by dialing (614) 424-5850 [300 Baud line] and (614) 424-5450 [1200 Baud line]. Plans call for this database to be updated on a two-year cycle. [See Attachment M.7 for complete directions to access the demonstration.]

The SubTAG has initated plans for an electronic bulletin board and has scheduled a workshop on tools, techniques, and concepts for workstation design. The latter effort, under STARS-funded contract to Carlow Associates, is scheduled for April 1986 at the Naval Postgraduate School in Monterey, California. A

separate UCI Working Group meeting in Albuquerque, New Mexico, is to be scheduled once plans for the workshop and DOD HFE TAG Meeting 16 have been determined. [The Workshop on workstation design has been scheduled for April 8-10 at NPS. No date has been determined for the Working Group meeting.]

Presentations made at the meeting included:

STARS. Mr. Larry Peterson (HEL) outlined the Software Technology for Adaptable, Reliable Systems Program, which evolved from DOD Mission-Critical Computer Resources (MCCR) needs. The mission of the multi-year, multi-dollar STARS program is to enhance software usability, maintainability and productivity by improving the state-of-practice in the acquisition, development and support of software for MCCRs. General objectives of the program are the development of operable workstations, enhanced training practices, standardized procedures, and accessible databases. [See Attachment M.2.]

USER, System and Environment Scaling. Mr. David R. Eike (Carlow Associates) described a STARS-funded effort relating to the development and validation of measures, methods, principles and criteria for scaling user characteristics, system usability and environmental complexity. The goal of this effort is to reduce complexity. [See Attachment M.3.]

User-Workstation Interface Requirements. Mr. David R. Eike also described a STARS-funded effort whose objective is to develop and validate a comprehensive set of user-workstation interface design requirements and tools which could be utilized by a variety of users, from managers to programmers. [See Attachment M.4.]

UCI/STARS Workstation Interoperability Consortium. Dr. Mark M. Brauer (Lockheed California Corporation) reported on his efforts to organize the 21 member consortium. The consortium, composed of key industry and technical society professionals in the UCI domain, has volunteered its time to support the overall objectives of the UCI SubTAG; and is intended to provide a forum for UCI information exchange among government, technical societies and industry groups. The consortium will explore and define common areas of need, UCI tools, methods and references; and will develop recommendations for consideration by the UCI SubTAG in the areas of UCI standards, guidelines, tools, methods and research. [See Attachment M.5.]

COPE. Mr. Michael D. McNeese (AAMRL) gave an overview of C^3 Operator Performance Engineering technology, describing user-computer interaction issues relevant to integrated analyses techniques for C^3 systems, adaptive aiding and integrated C^3 workstation design.

Mr. McNeese also gave a brief overview of the Rapid Intelligent Prototyping Laboratory (RIPL) program. [See Attachment M.6 for materials relating to these two programs.]

4.2.9 Voice-Interactive Systems -- Mr. Clayton R. Coler, NASA-Ames Research Center, Moffett Field, California

Agenda and Attendee List -- Attachment N

Mr. Coler reported that in addition to the meeting held on 5 November the group has scheduled a tour of the Naval Ocean Systems Center (NOSC) and ITT facilities and an additional technical session following the conclusion of the TAG. Minutes of both technical sessions will be sent directly to Voice SubTAG attendees.

Presentations at the 5 November session included:

NOSC's Role in Speech Recognition and Synthesis (Ms. Elaine Schiller). Current Voice Input/Output (I/O) activities at NOSC cover a wide range of applications including voice-entry to training devices; voice-interactive expert systems; and natural language understanding. Future work at NOSC is planned to emphasize Voice I/O C^2 operations and standardization of interfaces, data busses and Voice I/O hardware and software.

An Architecture for Parallel Proessing in Speech Recognition: The Trace Model (Dr. Jeffrey Ellman, University of California at San Diego). Dr. Ellman discussed current machine speech recognition limitations compared to the human ability to understand speech. Current machine systems tend to process information in a serial fashion, whereas humans are able to integrate a large amount of information over a short period of time. Dr. Ellman proposed a network system which, although not intending to simulate the function of the human brain, serves to produce results consistent with the results seen when humans process and understand speech. Focus will be on the integration of large amounts of information and, as recognition proceeds, checks will be made to determine if the recognition is tracking in a meaningful manner.

Interference Reduction (Mr. Stephen Smith, Rome Air Development Center). This presentation was an overview of the efforts at RADC in the development of a speech enhancement unit that cancels, in real time, three kinds of noise: impulse noise, narrow-band noise, and wide-band noise. The system currently is a large unit and is not so usable in severe environments. A contract has been awarded to fabricate a prototype unit that will be flyable in aircraft and usable in field situations. The prototype is expected to be available in March 1986.

Presentations scheduled for 8 November include:

1. Voice Interactive Avionics (VIA) Flight Test Preparations, Mr. Lockwood Reed, USA Avionics R&D Activity, Fort. Monmouth, New Jersey;

2. Software Methodology for Automated Recognition Training (SMART), Mr. David Williamson, AFWAL/FIGR, Wright-Patterson Air Force Base, Ohio;

3. Voice Research at the Human Engineering Laboratory, Ms. Kathy Christ, USA Human Engineering Laboratory, Aberdeen Proving Ground, Maryland;

4. Application of Connected Speech Recognition to Tactical Voice Command and Speaker Authentication, R. Wohlford and B. P. Landell, ITT Defense Communications Division, San Diego, California; and

5. DARPA Speech Research, Dr. Tice DeYoung, SPAWARSYSCOM, Washington, DC.

During the business session, new Roadmap forms were distributed. Roadmaps are summary written descriptions of Voice I/O projects. They document work in progress, including objectives, approach, results to date, and specific facilities and equipments being utilized. Roadmaps serve to inform members of the Voice SubTAG about ongoing work in other laboratories and stimulate more detailed information exchange between centers who have related work in progress.

In other business, Mr. Coler announced that Mr. Joe Pete Severo (ARI) has volunteered to provide the Voice subgroup with a document concerning the use of ARPANET. In the past, the ARPANET has served the SubTAG effectively by providing a means of information regarding new work efforts, new reports, and updated technical information. ARI will serve as the host of the new Voice ARPANET mailbox.

Mr. Coler reported that the SubTAG has undertaken the development of a User's Guide to Voice I/O Systems. The guide in intended to provide specific Voice I/O System information for new users. Mr. David Williamson (AFWAL) is in charge of this effort.

The group also discussed the need to document current state-of-the-art capabilities of Voice I/O systems and the identification of critical knowledge gaps, where needed information is not expected to be available in a timely fashion. This effort would serve to identify candidate areas for future research and development funding.

In closing, Mr. Coler expressed his appreciation to NOSC for hosting the 8 November technical session and to Ms. Elaine Schiller and Mr. Stephen Nunn for arranging the NOSC tour. Mr. Coler also reported that Ms. Schiller has been selected as the new Voice-Interactive Systems Chair.

5. PROFESSIONAL AND TECHNICAL PRESENTATIONS

5.1 Tutorial: Selecting Performance Measures in Human Factors Engineering Testing and Research

Moderator -- John L. Miles, Jr., J.D. (ARI)
Panelists
Army -- James C. Geddie, Ph.D (TCATA/HEL)
Navy -- Dennis K. McBride, Ph.D (PMTC)
Air Force -- Stephen M. Rokicki, Ph.D (OTEC)
APA/21 -- Frederick A. Muckler, Ph.D (APA/21 Representative)

View Graphs -- Attachments P through U

Dr. Miles introduced the panel members and gave a brief overview of the format and intent of the presentation. Dr. Miles noted that although the briefings were slanted toward those individuals directly involved in performance measurement, an awareness of the underlying problems would be of benefit to all attendees. According to Dr. Miles, no definition of a performance measure can be found in relevant dictionaries but the purpose of a performance measure is to select from the many facets of observable activity one (or more) which is assessable in relevant, meaningful quantifiable units. Dr. Miles suggested four reasons why performance measures are important:

1) validity of human factors technology;

2) communication of findings in units that have meaning for the user;

3) construction of databases; and

4) uses of new technology.

Dr. Miles reiterated that, at present, there is no one, best, universal performance measure. The most commonly used human performance measures are time and "accuracy," where accuracy is assumed to be a reciprocal of the measred error. There have been problems with this approach, necessitating a MANPRINT rule that says that time and accuracy are not independent of each other. Common problems with performance measures are that they are frequently set too broadly or too narrowly, they are often unrelated to military concerns and perhaps most critical, they often fail to discriminate.

According to Dr. Miles, the ideal source for performance measures would be the requirements document for the system; and ideally the requirements document would include operator performance standards, operator characteristics, and information regarding the maximum tolerable training burden (cost, length, etc.).

Human Performance Measurement: Context and Content -- Dr. Geddie

For systems recently fielded by the Army and for those still in development, it is typical for the life cycle cost projections for a system to show only about 20% of the total cost for the system to be absorbed by research, development and acquisition costs. The remaining 80% is absorbed by operation, maintenance and other support costs. This later 80% is heavily weighted with "people costs" to include trainers, operators, maintainers and others. Thus it has become increasingly apparent to Army planners that greater emphasis on developing systems which have an effective and efficient soldier-machine interface -- even at the expense of increasing the up-front acquisition costs -- promises soldier-machine systems whose total life cycle cost effectiveness is dramatically enhanced.

Soldier-Machine Systems vs Hardware

This increased emphasis on the soldier-machine interface has not been a sudden change. Instead it has been a gradual one coincident with and related to an increased willingness to think in terms of developing total systems rather than developing separate hardware, training, software, logistic support, technical documentation and facilities as separate efforts to be later combined into an effective system. It should be added at this point that the metamorphosis is by no means complete. There are many members of the acquisition community who still say "system" when what they really mean is "hardware".

At first encounter the difference between the two concepts may seem somewhat superficial, but it has fundamental implications for the way in which the Army develops new combat systems. It also has some profound consequences for testing and evaluating developmental systems.

During development, the systems approach requires that many players get into the process right at the beginning. The materiel developer, the combat developer, the trainer, the logistician and several others must participate in defining goals, requirements and limitations for the system. Unlike the somewhat fragmented approach to development mentioned above, the systems approach requires that each player participate in a trade-off process. In this process, an attempt is made to arrive at a cost-effective means of acquiring a new combat capability. Among the trade-offs which might, for example, be negotiated is a choice between (1) a hardware design which is high in acquisition costs but imposes human performance and skill requirements which are cheap to acquire and maintain versus (2) a hardware design which is lower in acquisition costs, but requires human performance and skills which may be very costly to acquire and maintain. Based upon the available cost predictions, the alternative meeting the system goals which offered the lowest life cycle cost could be selected. Now, what does all of this have to do with human performance measurement?

* Text provide by Dr. Geddie.

Implication for Performance Measurement

Once the focus of attention shifts from "materiel" to "system", the business of testing and evaluation becomes quite different from testing of materiel alone. In component level and even subsystem level testing, hardware functions are exercised in a way in which any human function is assumed to have a probability of 1.0 of being correctly performed the first time and every time, regardless of the conditions surrounding the performance. The concern in this type of testing is nothing more than "Did the hardware behave as predicted?". The assumption is explicit that failures due to human error are not chargeable to the hardware design. An implicit (and probably wrong) assumption of this approach to development and testing is that the combination of manpower and training resources available to the Army when this hardware is fielded will be capable of meeting whatever human performance requirements have been built into the system.

Testing and evaluation conducted under a systems approach acknowledges the influence of the human operator and his or her performance on total system effectiveness and reliability. Soldier-in-the-loop testing attempts to exercise the system using a sample of soldiers who by aptitude, training, experience, and physical characteristics are typical of those who will function as part of the system once it is fielded. An attempt is made to control the variation in this soldier sample by use of seletion criteria or at least to account for it with demographic data. Within available test resources, system functions are exercised over a representative sample of the conditions (terrain, weather, visibility, etc.) which are anticipated in use of the system in training and in combat.

In the interest of efficient use of test resources, human factors testing is frequently done concurrently with testing for other aspects of system performance. For example, in testing a vehicular system, data on critical driving tasks might be collected on the same exercises used to test reliability or durability of the vehicle.

Human Factors Test Data

Whether human factors data are collected in a separate test or during testing of some other aspect of performance, there are basically three kinds of information which will be collected. These are (1) engineering measurements, (2) user opinion, and (3) human performance data. Each has its own appropriate role in the evaluation and will be treated separately.

Engineering Measurements. When the project management office or the prime contractor on a given system begins to plan for human factors testing, engineering measurements usually are considered first. During establishment of the system goals, requirements and limitations, applicable sections of military standards and

specifications should have been cited as design standards to be met. The requirements document may also specify military handbooks and other sources of guidance to be used in hardware design. In general, engineering measurements are the data used to evaluate compliance with these requirements. The required data may often be collected without participation of the human component of the system and may address requirements in such areas as:

size
weight
lighting level
noise level
crew workspace layout
ingress and egress provisions
temperature
vibration
display brightness, legibility and labeling
control placement and force requirements.

User Opinion. This second category of information collected for a human factors evaluation is used to learn from test participants, test control personnel and observers about characteristics of the system which might not be revealed by engineering measurements. It is generally accepted that troops will not function at optimum effectiveness with equipment they dislike or mistrust, thus limiting system performance. Obviously, the most direct way to find out how a user feels about the equipment is to ask his opinion. The user's insights -- after he has attempted to function with the hardware and procedures as part of a total system -- also can sometimes suggest improvements in hardware design or in operating procedures which would not be revealed by checking for compliance with specifications and standards. Problems reported by users may also identify system characteristics which merit close scrutiny during human performance testing.

Human Performance Data. The overall goal of a human factors engineering program is to insure compatibility among (1) the soldier, (2) the training, (3) the tasks, and (4) the equipment. Having compared the hardware characteristics against human engineering standards and trained a sample of soldiers and elicited opinions of the equipment and training, the remaining task in determing whether the human factors engineering program has met its goal is exercising mission-critical soldier tasks and collecting and analyzing performance data on those tasks.

Collection of these data must be based on a review of the human performance requirements associated with the system. If the performance requirements have been properly specified in the requirements documents and a useable task analysis is available, a good start has already been made on identifying tasks on which to collect human performance data. Other inputs to the task selection process should include technical manuals and training

materials used in training test participants. The list of tasks to be included should have as its highest priority those tasks whose performance defines an outer limit on total system performance (e.g., in a tank system: loading, laying and firing the gun).

There are two basic measures used in human performance measurement: human performance time and error rate. For each task exercised and measured in the test both kinds of data must be collected on each event. The reason for insisting that both measures be made of each event is that for most tasks, performance time and error rate can be traded off one for the other. The set established in the test participant can radically affect whether he or she emphasizes speed of performance at the expense of accuracy or conversely, accuracy at the expense of speed. For some tasks, the trade-off function itself may be more important than either data point alone in affecting both design changes and operational doctrine for the system.

Analysis of these data should first compare achieved performance against the performance goals established in the system requirements documents. If the system's front-end analyses have been thorough enough to define criteria for task performance, they define the test criteria. In the case of systems for which the criteria have not been stated, the performance data are used in predicting what the performance in the field will be. The question of "How good is good enough?" then gets a post hoc answer, but at least the decision of whether to accept a system can be an informed one, based upon knowledge about currently achieved performance.

Another use -- perhaps a more important one -- for these data is identifying areas in which human factors engineering design improvements have a high potential payoff. If, for example, the data show an unexpectedly long performance time for one of a series of sequentially performed tasks, that task would be identified as a priority candidate for improvement in the hardware associated with it or the procedures for performing it. Consideration might also be given to machine aiding or to automating part or all of its performance.

Soldier-Machine System Evaluation

The bottom line for evaluation of a soldier-machine system has been reached when the evaluator has answered the question, "So what?", for each test issue. The specifications and standards against which we evaluate engineering measurements should be met. Their criteria have been developed from experience with many past systems and meeting those criteria improves the probability of acquiring an effective and efficient soldier-machine system. However, meeting those requirements does not insure that this has been achieved, nor does failure to meet one or more of the criteria insure an unsuccessful system.

Likewise, the user's feelings and attitudes toward the system are important. The Army has demonstrated too many times that a system that is not liked or trusted by the users has little chance of operational success. However, it is critically important to keep in mind that there is not a one for one correspondence between equipment characteristics about which users complain and equipment characteristics which can be shown to degrade their performance or total system performance. In competitive testing it has also been observed that soldiers often state a preference for an equipment design with which their performance is worse than with a less liked competitor. The lesson we must acknowledge from that reversal is that the user can give us his feelings about how well he likes a system, and is seldom reluctant to evaluate its and his performance, but regardless of how precisely and accurately we may measure those feelings and attitudes, they have (at least in my small sample of opportunities to compare them with objective performance data) been observed to have no correlation with objectively measured performance.

The indications from engineering measurements and from user input are important in a system evaluation. They should influence the selection of tasks for human performance testing. Obviously, if an equipment characteristic clearly violates a human engineering standard or users feel that it significantly degrades their performance, that characteristic merits closer examination. But both the system and the human fators profession and technical area are done a disservice when we attempt to evaluate system performance or human performance as one of its components without measuring the performance. The risk to the system is simply that our evaluation may be wrong and we end up "fixing something that isn't broken" or accepting a system with design errors that reduce performance without our even knowing that performance has been reduced. The long-term damage to human factors may be much more significant. Human factors as a discipline is continually challenged to document its value to system design. When we justify decisions to change (or not to change) a system's design upon a prediction of performance consequences, then base those predictions upon anything less than hard performance data, both our credibility and future acceptance of human engineering inputs are jeopardized.

Put a bit more colloquially,

> if we want to know whether the materiel design has complied with the system specification and with applicable criteria in the standards, engineering measurements are appropriate; if we want to know whether the user likes it, user opinion is appropriate; but if we want to know how well the humans in the system perform, and how their performance relates to total system performance, there is no defensible substitute for human performance measurement.

The Navy Experience -- Dr. McBride

Dr. McBride reported that there are a number of areas on which aircrew performance measurement impacts, including the mathematical modeling of pilot behavior, workload evaluation, aircrew training, evaluation of aircrew perceptions and decisions, etc. A typical example of performance measurement in the aircrew environment might be that of the measurement of deviation from a prescribed course of actions. Dr. McBride noted that most of the processes utilized in flying aircraft are available for our examination and measurement, whether they be perceptual, motor or physiological. The aircraft also provides outputs from aileron movement, attitude direction indicator, etc. and from 1553 data thruput. In terms of man-machine output, other specific measures could be aceleration, altitude, airspeed, error measurements, etc. Other measurements from this high workload environment include frequency measurements such as number of control losses, number of control reversals, number of correct responses.

There are also some combined overall measures available -- grid stick index, landing performance score, objective mission success scores, trials to criterion. According to Dr. McBride, the range of measurements is wide -- from use of "rule of thumb" measurements through to sophisticated measures such as the Dopple-measured blood velocity at the level of the brain.

Dr. McBride concluded his presentation by reminding the TAG that there are a number of parameters of measurement that must be considered, including fidelity of test conditions, cost of the measuremetn system, ease and flexibility of testing, control, and data accessibility. Since no one measure is high on each of these scales, it is necessary to titrate and use the scales as best one can. For additional information on performance measures, Dr. McBride recommended that interested individuals obtain a copy of the January 1982 Naval Training Equipment Center Technical Report IH-330 by T. R. Mixon and W. F. Moroney entitled <u>An Annotated Bibliography of Objective Pilot Performance Measures</u>.

Human Performances Evaluation in Air Force Operational Test and Evaluation -- Dr. Rokicki

Dr. Rokicki reported that the current approach to human factors evaluations at the AF Operational Test and Evaluation Center is that it may not be necessary to do complete human factors testing on every system: that in some systems human performance may not be critical. Since hardware, software, human performance and the mission comprise total system performance, there are cases in which it is not necessary to have optimal human performance: if the system performs well, then effective and acceptable human performance may be all that is required.

Dr. Rokicki noted that Air Force operational test and evaluation concentrates on two principal areas. One area is the

dynamic approach to the man-system and group interaction, where the major questions are "does the system constrain/prevent the human from doing his job?" and "does the human hinder the performance of the system?" The other area of concentration is a focus on intrinsic human performance in terms of physiological and psychological decrement and fatigue/workload issues. Evaluation techniques include:

- workload analysis
- facility and workstation evaluation
- error rates
- display-task analysis
- environmental evaluation
- small group analysis
- behavioral analysis.

Workload Analysis. Since high workload degrades operator performance, OT&E utilizes a variety of workload analysis techniques, including the Subjective Workload Assessment Technique (SWAT), the modified Cooper-Harper Scale, physiological correlates and other objective and subjective measurements.

Facility and Workstation Evaluation. To determine if the design/configuration of a system prevents/hinders/limits operator performance, operational evaluations are made of the system layout and console layout. These evaluations are intended to provide a dependable base to assess operational impacts.

Display-Task Analysis. These analyses are performed to determine if the display formats and presentation sequences are adequate for the operational tasks. Technical evaluations of the formats and controls, observations, subjective reports and video tapes are part of this type of analysis.

Environmental Evaluation. In the Air Force, environmental evaluations are normally done during developmental test and evaluation (DT&E). However, conditions under which DT&E is done may not always reflect operational conditions; and acoustics, lighting, temperature control, humidity, etc. can affect operator performance as well as the hardware/software components of the system.

Behavioral Analysis. One of the techniques used by the Center is that of analyzing the cause and effect of critical incidents involving operator fatigue, workload, stress, etc. These postmortem analyses are only done if the critical incident adversely affected system performance. According to Dr. Rokicki, this focus saves time, money, and manpower.

In closing, Dr. Rokicki reiterated that although there are specifications and standards for other system components, there are no specific task standards nor parameters for human performance; and at present, there is no universally accepted

human performance evaluation methodology. These issues need to be addressed but Dr. Rokicki suggested using caution when developing standards for human performance due to the tremendous variations in human behavior.

Selecting Performance Measures: Some Practice and Some Theory -- Dr. Muckler

Over the last 25 years, Dr. Muckler has participated in a number of developmental and operational tests of man-machine systems and it has been his experience that in each of the tests some aspect of human performance measurement has been a serious problem. Focusing on 22 operational system tests in which he was involved in the last three years, Dr. Muckler noted some general characteristics of these tests. According to Dr. Muckler, each testing situation represents a new configuration -- calling for judgements as to which measurements will be of the most value. The high cost of tests and the severe time constraints posed impact both the test plan and conduct. Users of the test data often prefer simple measurements; and since there are differing viewpoints as to purpose of the testing, it can be difficult to reconcile evaluative versus diagnostic approaches. Other constraints concern a particular measurement's "acceptability": i.e., is the measurement the appropriate one or appear to be the appropriate one for the parameter(s) being assessed? Problems also arise due to the great differences in the experience and training levels of the testers, evaluators and those responsible for the system being tested. Although there is a strong demand for "expert judgements," there is also a marked resistence to human performance measurement.

Instrumentation can also contribute to test difficulties: not all facilities/situations have adequate instrumentation for the task(s) at hand and it may be possible that what ends up being measured is directly related to how much instrumentation can be made available. On the other end of the instrumentation availability issue is the situation in which a complete, automated computer-based performance measurement system is utilized. In this instance, the sheer amount of data collected may result in an "overkill" situation in which there are too many data points to analyze in a timely, meaningful way.

Dr. Muckler indicated that these problems will continue unless improvements are made in human performance measurement. While there are some situations in which quantitative models are available and can be easily utilized, in most cases the test plans are the result of the test team's personal methodology.

Dr. Muckler posed a model for performance measurement, noting that the basic question underlying any measurement should be "what do I need to know?" The first step in Dr. Muckler's model is an information needs analysis. The second step is a performance objectives analysis and deals with the issue of defining standards for performance. The third step is an analytic process in which

one separates out the necessary and sufficient set of performance parameters (state system identification). The information gleaned in these first three steps is integrated; and in step four, measurement dimensions are specified. Dr. Muckler noted that these first four steps are the "what" steps of the model and initially, should be kept separate from the "how" steps.

Once one has determined what he needs to know, the next step is how to get the necessary data and since there are alternative measure sets for most of the measurement dimensions determined in step four, it becomes necessary to compare these alternatives. According to Dr. Muckler, potential criteria for determining which measurement set to use include:

- validity
- reliability
- generalizability
- utility (cost)
- precision
- nonreactivity
- acceptability.

Dr. Muckler noted that not all test personnel are acquainted with the concepts of validity and reliability. It is also necessary to determine the level of precision required; if this is not done, the quantity or quality of the data may render it unusable. It is also necessary to guard against having the process of measuring interfere with the parameter being measured: some measurements are more reactive (intrusive) than others. Two aspects of generalizability should be considered: 1) internally, has the subset been selected that allows generalizations and 2) can generalizations about the data be made across all classes of systems. Other criteria for selecting a measurement set include costs involved in the data collection (instrumentation, personnel, time, etc.) and whether the measurement set is acceptable to those responsible for the system being tested.

Step six is the preliminary testing of alternative measures and Dr. Muckler indicated that it is not always possible to do this stage. When the opportunity exists, however, three aspects should be considered: the resources available/necessary to conduct a quality test, the instrumentation and data processing requirements, and methods of checking the quality of the data during the measurement process. All the above steps culminate in the installation and operation of the final measure set.

In closing, Dr. Muckler reported that, with respect to measurement, there is the implicit assumption that if more data is collected, all problems will be solved. This concept of "if it moves, measure it" may be self-defeating: the issue may be confounded rather than clarified. Dr. Muckler also suggested that this shotgun approach is not a good practice and he suggested that there be a justification for all data points collected.

[For additional information on performance measurement development, Dr. Muckler recommended D. Meister's Human Performance of Systems, in preparation, 1986.]

COMMENTS, QUESTIONS AND ANSWERS FOLLOWING THE TUTORIAL

C. I'm curious about the combined overall measures that Dr. McBride alluded to. I wonder what hope we have of getting away from time and accuracy, frequency, etc. What hope do we have for some derived, combined numbers?

McBride: Obviously, combined measures are more informative than simple measures. Selection of a measurement, in general, is results driven -- a top down approach. The idea is that it is the original question which drives the selection of performance criteria. If a combined measure seems to be more relevant, select the combined measure.

Muckler: One of the most exciting theoretical exercises for me has been developing new ideas of composite measures; and in the situations I've been in, there is a large amount of basic data and parameters for so doing. To date, I've been unsuccessful in proposing a composite measure but I intend to keep trying.

Q. Dr. Rokicki mentioned going from optimal human performance to "effective." Could he explain a bit more of what he means by effective and how effectiveness is measured?

Rokicki: Basically, that approach arose from a briefing on how we are operating and the methodologies that we are using. A pilot doesn't have to fly an airplane at total peak performance all the time: he has to be capable of carrying out the mission but he doesn't have to perform in an optimal manner.

However, I can't really answer the question as to how effectiveness is measured -- basically, "effective" means the ability to complete the mission.

C. On the matter of error measurement, I would like to mention that in the last couple of years I have encountered two situations where it was not at all clear what was an error and what was not. These were in connection with an anti-aircraft missile system and an anti-aircraft gun system. Both of these were in target-rich, hot and heavy environments, with a number of alternatives that the crews could pursue at given points in the engagement. In some cases it was not at all clear that one alternative was right or wrong, or even that one was better than the other, so it's not a simple problem.

Q. A few years back, the Test and Evaluation SubTAG discussed the difference between task analysis and critical-task lists. MANPRINT seems to stress the need for critical-task lists and my

question to Dr. Geddie is do we have to go back to a fullblown task analysis or, for the purposes he mentioned in his briefing, would a critical-task list of high drivers suffice?

Geddie: Probably for testing and evaluation, a list of critical tasks -- not a fullblown task analysis -- would suffice. I would hope, however, that the prioritized list of tasks also would imply some kind of performance criteria against which we can measure. Preferably, we'd be able to measure both performance time and error rate and have some criterion to compare them against. If the question was "is a fullblown task analysis required?", the answer is not necessarily.

C. Would Dr. Geddie enlarge upon his comment that hardware failure is not charged to system design.

Geddie: That comment comes from my experience in developmental testing. In the reliability community, at least within the Army, there has been a 10-12 year battle to try to persuade the people who calculate system reliability and predict what it will be when a system is fielded not to regard every human error as something that is not chargable against hardware design. In AMSA we provided two calculations of systems reliabillity. One of which was clearly labeled as hardware reliability. The other accommodated human error as part of the number. My original comment concerned the practice of doing straight hardware testing which disallows any kind of human error induced failure.

C. A specific example might be in testing a tank in a very fluid battlefield. Eight targets go by but because there is confusion over the status of four, they are not engaged. The last four are successfully engaged. In this example, the weapon system would be scored 100% effective even though we might be very uncomfortable with the fact that half the time the target went by. But because the system wasn't engaged, the first four were not charged to the system.

Miles: I have listened to some very articulate arguments from contractors who say that just because your operator tripped over his bootlace and therefore didn't engage the system, you can't charge that against the hardware. The hardware was there and was ready. This approach misses the subtlety of the fact that sometimes the designs of the hardware induce the operator to make the errors that cause the system not to work.

Muckler: It has been interesting over the years to see the waxing and waning of the two extreme points of view -- in one, there is no such thing as a human error. The other side says that if a human makes an error, it is entirely the fault of the equipment.

C. I've enjoyed all the presentations but I think someone should mention the fact that all tests and all evaluations are only as good as the initial test plan. Also, the people who are

involved in the testing need to be disciplined and very much aware of the importance of what they are doing and not interfere with the very processes they are measuring.

Muckler: Under the rules of the game, the whole process starts with the requirements document. However, in nearly one system out of five, there is no requirements document despite the fact that it is mandatory or, it is a requirements document that is useless to you. We often have to make it up as we go along, so that there will be a requirements document. Also, we try to train our test people as rigorously as possible, simulating the situation before we do the actual testing. After 12 hours in the mud, though, it can be hard to be disciplined.

5.2 Implementation Efforts for MANPRINT -- Mr. Judah Katznelson, US Army Research Institute for the Behavioral and Social Sciences, Alexandria, Virginia

See Attachment V for the report and visual materials submitted by Mr. Katznelson.

5.3 State-of-the-Art in AI/ES, Decision Aiding and Augmentation for Advanced Military Systems -- Dr. Thomas M. Cook, Martin Marietta Aerospace Company, Denver, Colorado

View Graphs -- Attachment W

According to Dr. Cook, his current definition of artificial intelligence is the attempt to produce a computer system(s) (hardware, software, displays, peripherals, I/O devices, etc.) that can perform complex tasks that normally require human intelligence. AI seeks to enhance the performance of humans in difficult situations. Related areas under AI include:

- expert systems,
- natural language understanding,
- image understanding and pattern recognition,
- intelligent robotics,
- advanced computer architectures, and
- intelligent decision aids.

Research and applications in the expert systems area are primarily involved with the development of programs and systems to assist the human and, in many cases, raise human performance to the level of a true expert. Current application areas in which a substantial amount of money is being invested by DOD are the DARPA Strategic Computing Program, the Battle Management Program, and the Space Station Program.

Relating his briefing to some of the issues discussed during the performance measurement tutorial, Dr. Cook noted that the Autonomous Land Vehicle (ALV) program provides well defined performance measures. Initially, the ALV had to demonstrate its ability to maintain road contact. In the second phase, the ALV

needed to demonstrate that it could maneuver on a relatively straight road at five kilometers per hour; and within the next few months, ten kilometers per hour will be performance parameter measured. In two to three years, it is expected that the ALV will be able to demonstrate its ability to maneuver across rough terrain.

Battle Management is a program being approached by all the services. The three major areas being emphasized are:

1) command, control, communications and intelligence work;

2) staff planning/replanning; and

3) Pilot's Associate in which state-of-the-art applications are provided to the pilot to assist him in difficult situations.

Dr. Cook reported that there are a number of artificial intelligence applications across the services and within the Department of Defense and NASA. These applications include:

. human-equipment interface aids such as smart displays, voice input/output, voice recognition;

. planning and monitoring aids to help the average user achieve a level of expertise;

. expert advisor: providing the processes and information that the true expert uses to a wide variety of users;

. data access and assimilation (intelligent database management);

. support systems such as those being utilizd in all phases of the launch/mission control/recovery process of space vehicles;

. situation assessment: taking large amounts of information and integrating it into a meaningful analysis;

. system controllers;

. information collection; and

. training and instruction, using intelligent computer-aided instruction.

Dr. Cook reported that one of NASA's major thrusts for the development of AI and expert systems is the Space Station Program. According to Dr. Cook, Congress has mandated that ten percent of the $8 Billion Space Station budget (design and building phases) be dedicated to advanced automation and he anticipates that at least 30 % of the advanced automation aboard the Space Station will be in the area of intelligent systems. At this point in

time, the fault management area is receiving the most emphasis. This deals with detecting, isolating and coping with a particular fault condition; and Dr. Cook reported that there are currently 20 expert systems being built to address the fault management problem. Other AI and related technologies applications within NASA include: the satellite monitoring and control area, intelligent robotics and the development of intelligent autonomous spacecraft.

Dr. Cook discussed some of the problems relating to available resources for AI type programs, noting that there is a significant shortage of trained personnel capable of building AI systems. The majority of the individuals doing AI type work are being trained at major universities such as M.I.T., Stanford, Yale; there are a limited number of universities, according to Dr. Cook, that have good programs in this area. Attempts at having the service and NASA train their own AI personnel, while successful, have created new problems. As a result of this training, the experts become quite valuable to the marketplace and NASA/government agencies can not afford to retain these people. In addition, a number of academics are going into industry, creating a drain on the basic research community.

One of the other difficulties is that of finding the "true expert" and capturing his knowledge and experience. Dr. Cook reported that there have been cases of expert systems being built where the individuals making the inputs were more "available" than "expert." Also, since there are relatively few true experts, they can command rather large fees: getting the level of expertise necessary has become a very expensive situation.

Dr. Cook indicated that the hardware necessary to build very sophisticated AI applications and expert systems currently exists. In fact, according to Dr. Cook, more computing power is available than can be currently utilized. Dr. Cook stressed that, to implement AI/expert systems programs, the government and NASA will need to be able to build systems that are small, powerful, radiation-hardened, and which can accommodate single-event upsets.

In the software area a number of powerful development tools have been introduced during the past few years; and Dr. Cook expects that these software programs will enable NASA and DOD to take individuals who are not fully AI trained and allow them to develop some of the application areas.

In closing, Dr. Cook outlined a technology assessment done for the Space Station Program, noting where problems and solutions had been found.

5.4 Crew System Ergonomics Information Analysis Center (CSERIAC) -- Mr. Steve Heckart, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio

View Graphs -- Attachment X

Ergonomics is the integrative discipline devoted to understanding and quantifying human physiological and behavioral interaction with equipment and systems; and although much pertinent ergonomics data exist, the information currently is widely dispersed and is not readily accessible. A survey of government, industry and academic crew station ergonomics data users indicated that a central, responsive DOD focal point in crew station ergonomics is needed. Of those responding to the survey, 97% use crew station ergonomics data in their work and the products/services they need most are :

- state-of-the-art reviews and technology assessments,
- rapid response to technical inquiries, and
- current awareness bulletins.

Eighty-eight percent of the respondents supported the establishment of CSERIAC and 79% indicated a willingness to pay for CSERIAC's services.

The current proposal is that the Air Force Armstrong Aerospace Medical Research Laboratory (AAMRL) serve as the host of this analysis center with the focus being on crew system ergonomics for military aircraft and space vehicles. The short term focus of the CSERIAC is on airgoing crew systems. However, the long-term goal is that CSERIAC would provide the model and experience base to support the development of other specialized human factors information analysis centers hosted by DOD agencies. Thus, in the future, it is possible that the focus of CSERIAC would be enlarged from airgoing crew systems to include the needs of specific users.

Potential users include government laboratories, evaluation agencies, Systems Commands, the Pentagon and the logistics and intelligence communities. Industry users might include prime or subcontractors, systems and operation analysts, and the controls, displays and software communities.

Subject domains of CSERIAC would include design methodology, human performance characteristics, information display interfaces, motor/control systems characteristics, and specialized-design issues.

As currently envisioned, the functions/services of CSERIAC would be in the areas of:

- rapid expert consultation and support,
- problem solving and analysis,
- author compendiums/handbooks of selected ergonomics data,
- MIL STANDARDS and SPECIFICATIONS, and
- identification of high-value technological gaps/voids.

CSERIAC could also provide a recognized liaison with a variety of user communities and could support the planning and conduct of workshops, symposia, conferences and short courses.

5.5 Vision in Spatial Disorientation and Loss of Aircraft Attitude or Control Awareness -- Colonel Grant McNaughton, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio

View Graphs -- Attachment Y

Colonel McNaughton noted that the purpose of the briefing was to provide insight into how orientation and attitude information is processed and to point out some of the design features that impede valid information acquisition and, therefore, impede appropriate action. Colonel McNaughton enlisted the support of the TAG for fomenting pratical improvements in present aircraft and requested that these issues receive due consideration in the design of future aircraft. He also indicated that the aspects covered in the briefing should be of use to those who are involved in mishap prevention and mishap/accident analysis.

Historically, spatial disorientation (SDO) has been considered as a mismatch between vision and the balance organ. However, current information indicates that the mismatch between the vision system itself and its two modes of processing visual information (focal and ambient) also plays a major role in SDO. The focal mode is an object recognition system that is exclusively visual and requires good lighting and optics and typically involves conscious attention. The ambient mode is concerned with object quality (quality of the surrounds) and is uncritical: it can easily be deceived. This mode includes vision, balance, proprioception and hearing. In essence, according to Colonel McNaughton, it is more of an ambient orientation system in which vision contributes inputs along with those from the other senses. The ambient system carries most of the workload and works at any lighting level. Resolution is totally unimportant: the system works at the reflex level.

The three major consequences of ambient mode reactions involve distraction potential, vection illusion, and false horizons. Since the brain contains receptors specifically responsive to the components of motion (velocity and direction), any motion attracts the eye. These responses are reflexive and extremely difficult to suppress. Pilots trained to detect bogies and avoid mid-air collision are especially impacted since any object motion can also cause head motions and these head motions can further add to the pilot's disorientation.

Whereas a small amount of motion on the periphery can be interpreted as object motion, more of the peripherative moves can be interpreted as "self" motion. This vection sensation can be true or illusory and is the principle upon which full visual simulators are based. According to Colonel McNaughton, one of the design features that potentiates vection illusions is a

bubble-shaped canopy in which the position of the pilot's head is such that his ambient mode is subjected to maximum bombardment -- glare reflections, false motions, etc.

Colonel McNaughton also noted that findings indicate that the visual cortex contains receptors specifically responsive to lines and edges. Since the human cannot tolerate a sense of disorientation and the ambient mode is uncritical, it is likely to accept anything with the quality of "horizoness." Since it appears as if the larger the horizon, the more commanding it is, this impacts the way aircraft attitude displays should be designed. Colonel McNaughton reported that a night departure across a lighted shoreline is particularly lethal because the balance organ cannot distinguish between acceleration and a climb. As what appears to be the horizon passes beneath the pilot's wingline, he becomes convinced that he is doing a loop and his tendency is to dump the aircraft's nose, flying back into the water. It is currently thought that surface features that resemble horizons have been responsible for a number of mishaps.

According to Colonel McNaughton, problems with current aircraft include:

- wide-area canopies;
- inadequate attitude references (airframe and instrument);
- failure to provide critical control parameters (airspeed, altitude, etc.) in a digestible format;
- lighting problems;
- attention traps (caused by head down locations); and
- denial of important non-focal mode sensory cues (tactile and auditory).

Colonel McNaughton discussed mishaps involving particular aircraft, noting where the above problem areas may have contributed to the mishaps.

One of the major needs of the pilot to help him recognize, combat and cope with the problems associated with spatial disorientation and false/no horizon is that of the enlargement and position of the attitude indicator. Colonel McNaughton stressed that ADIs need to be prominent, large and in a central location. Ideally they would be large enough to see out of the corner of the eye, especially when flying in formation. According to Colonel McNaughton, all current ADIs suffer from the same human factors problem, e.g. the roll sensor is reversed; and when under great stress, it is possible for even experienced pilots to become momentarily confused.

Since man is basically a pattern recognizer, the more one visually organizes his information, the faster he is able to acquire and understand the information. Colonel McNaughton noted that a pilot's major concern when looking at his displays is whether the parameters represented have changed; and, if so, in which direction and by how much. The problem with digital, alphanumeric, and symbolic displays is that they require attentional resources (focal mode) to read, decode and integrate. These displays do not provide inherent trend nor limitation information. On the other hand, properly designed analog displays can cue both the focal and ambient modes. These displays provide the information more quickly and can also provide trend/limitation information. However, problems occur because these displays are more easily misread.

Some of the problems with head up displays (HUDs), as currently designed, include their reliance upon the focal mode (digital display), the amount of information being displayed (clutter) and the methods/locations in which the information is being displayed (confusion). Head up displays, in Colonel McNaughton's opinion, are not basic attitude indicators, since there is usually a limited field of vision, no distinction between the sky and the surface, and the horizon line as a zero degree pitch line is no more commanding than any other pitch scale. In unusual attitudes, the HUD is subject to misinterpretation; and there is a tendency for pilots to stare at the HUD without actually processing the information.

Colonel McNaughton recommended that the following aspects be considered in improving/modifying current aircraft:

<u>HUD (instrument mode)</u>

- utilize a vertex pointer on the flight path marker;
- radically change the pitch scale pattern between positive and negative and within negative;
- consider color change(s) as redundant cue(s);
- lengthen all pitch scale lines; and
- consider a patterned analog format for parameters such as the airspeed indicator, attitude, vertical velocity indicator, angle of attack and gravity.

<u>ADI</u>

- provide dedicated attitude indicator;
- located high in the center of the instrument panel;
- consider HUD control panel area for projected image;

. colocate ADI and Standby Attitude Indicator for rapid mismatch recognition;

. improve nonvisual cues to airspeed (radical pattern changes in different ranges);

. improve spot lighting;

. reduce glare and reflections (glare shields extensions/batwing shades);

. utilize a ground proximity warning system; and

. utilize a radar altimeter.

Colonel McNaughton's suggestions for improvement in future aircraft included:

- make improvements in the HUD for attitude, as noted above;

- utilize a dedicated ADI on the HUD control panel;

- utilize a dedicated ADI/SAI below in HUD control panel (different information source);

- optimize mixture of sensory inputs; and

- consider mission diversity (basic instrument flying, night formations, etc.).

In closing, Colonel McNaughton reiterated that man is a creature of habit: special care needs to utilized when locating switches, ejection handles, and critical instruments. Designers also need to give serious consideration to providing the pilot with the necessary attitude, airspeed, altitude, etc. cues in an easily recognizable and understandable manner so that his focal mode processing is not tied up; thereby, freeing the focal mode for those tasks specifically requiring the focal mode. By lessening the focal mode workload, situational awareness is improved and the potential for spatial disorientation is reduced.

[See also 4.2.1 and 5.6, these Minutes.]

[It was not possible to include all of the specific details noted by Colonel McNaughton in his presentation. Individuals desiring a copy of briefing tapes, should contact the TAG Coordinator, Louida D. Murray, at (303) 979-7441.]

5.6 Head Up Displays as a Primary Flight Instrument -- Dr. Richard J. Schiffler, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio

Over the past few years, there has been considerable concern as to the role head up displays play in aircraft accidents. In June 1983, Headquarters Tactical Air Command held a conference to address HUD issues. At that point in time, TAC policy was that a HUD was not considered to be a primary flight instrument. Other concerns discussed at the conference were the degradation of instrument flying skills and methods of training pilots to use the HUD.

In June 1985 a USAF-wide conference was held at Langley Air Force Base with the primary purpose being that of the development of a USAF policy on HUDs and instrument flying. Presentations were made by the Air Force Inspection and Safety Center, the Federal Aviation Administration, Aeronautical Systems Division/EN, Tactical Air Command, the Instrument Flight Center and a number of laboratories. Although the conference did not formulate a definition of what constitutes a primary flight instrument, there were a series of recommended policies regarding HUDs. These recommendations, now under review, include:

. any instrument flight system (including HUD and head down displays) should include control, performance, navigation and failure information; and

. head down information is still needed as backup information.

Dr. Schiffler reported that 33 F-16 pilots at Nolles Air Force Base and 35 A-10 pilots at Myrtle Beach Air Force Base were surveyed in 1982-83 in an attempt to determine eye position during different mission segments. Interview data was also collected on the percentage of time the HUD was used during different mission segments. In the F-16, low use of the HUD was reported during the take off, climb, cruise and low level segments. In the weapon delivery segments, the HUD was used as a primary instrument. This finding is consistent with expectations, considering the type of information displayed on current HUDs. Surveyors did note that in the approach and landing mode the HUD was equally used across the low and median high.

In the case of the A-10 pilots, results were similar: only in the weapon delivery mode was there high HUD use as a primary instrument. The pattern in the approach/landing mode was different from that of the F-16 group. Dr. Schiffler indicated that these differences may be due to the nature of the A-10 HUD. This older HUD has a narrower field of view than does the F-16 and there is less symbology information displayed.

Conclusions drawn from the review of the survey data were:

. overall, the use of the HUD is normally distributed;

. there is high use of the HUD during the weapon delivery task;

- there is low use of the HUD during takeoff, climb, cruise, and low level flights;

- there is no consistent relationship between HUD use and pilot experience;

- the F-16 HUD tends to pull pilots forward in the cockpit, thus making more information available; and

- most pilots prefer a 20° field of vision.

Many problems with the HUD need to be resolved if it is to be utilized as a primary flight instrument. The HUD does not provide adequate attitude information and the compelling quality of the HUD may interrupt normal crosschecking processes. Also, vertigo may be induced if it is necessary for the pilot to switch repeatedly from a head up to a head down position to access all the pertinent information. The HUD has a narrow field of view, limiting the peripheral cues necessary to determine spatial relationships and the location of enemy aircraft. In addition, the amount of information displayed may made the HUD difficult to read during certain regimes and current failure modes are inadequate.

Dr. Schiffler noted that the F-18 HUD has advantages over the F-16 HUD in that the F-18 HUD has a horizon line, a pointer indicates position in space, and roll information is included on the bottom of the F-18 HUD. The Navy has a major effort underway, studying in part, the F-18 HUD as a primary flight instrument. According to Dr. Schiffler, the F-16 System Program Office has tasked ASD with addressing these issues as they relate to modifying the present F-16 HUD to make it a primary instrument. ASD will utilize its man-in-the-loop simulation crewstation design facility, testing operational pilots with differing experience levels. In the F-16 simulator, HUD information is generated and superimposed on a closed circuit television system. Pilots fly mission scenarios and the investigators collect performance and workload data. A variety of studies have been planned, utilizing different methods of presenting roll information, altitude and attitude information, etc.

In conclusion, Dr. Schiffler reiterated that HUDs have been and will continue to be used in a primary instrument fashion. More research must be done to determine what information the pilot needs, head up or head down, to recover from various flight regimes.

5.7 Human Factors and Organizational Systems Laboratory, Navy Personnel Research and Development Center -- Dr. Robert E. Blanchard, Navy Personnel Research and Development Center, San Diego, California

Navy Personnel Research and Development Center is the principal Navy research, development, testing and evaluation

center for manpower, personnel, education, training, and human factors and provides technical support to the Chief of Naval Operations in these areas.

The Center's basic goal is to perform both field and laboratory RDT&E and simulation work that will increase the Navy's readiness and effectiveness. Current and anticipated problems in manpower management, personnel administration, organization management, education, training, and human performance are considered. The Center is organized around three R&D laboratories: (1) Training; (2) Manpower; and (3) Human Factors and Organizational Systems.

The Human Factors and Organizational Systems Laboratory is concerned with developing and conducting an R&D program to advance the behavioral technologies supporting an improved understanding of man's interaction with other individuals and complex hardware systems. The program addresses social, technical, and physical environmental factors for enhancing performance and improving the quality of working life.

Since the Navy is increasingly dependent upon complex combat and support systems, the Human Factors Department within this laboratory has responsibility for developing and conducting R&D to extend the fundamental knowledge of human processes underlying advanced concepts and models of human-machine functions. Resulting principles, techniques, and data are organized and applied with an integrated systems approach that seeks to optimize the design, development, operation, and maintenance of Navy human-machine systems. Major program activities include:

1. Providing human factors support to the development of command and control (C^2) systems.

2. Expanding the application of human factors principles to the design and development of new systems.

3. Providing RDT&E to augment and stimulate human factors efforts in the design and development of new systems.

4. Improving the effectiveness of individuals and teams by application of principles of human performance.

5. Ensuring the application of human factors principles and data to Navy systems throughout their life cycle.

6. Applying mathematical models to enhance decision-making capabilities of advanced combat systems.

To achieve maximum readiness within the limits of available resources, the Navy must also develop the full potential of its human resources and apply that potential toward maximum productivity. The Organizational Management Systems Department has this responsibility. This program develops and conducts R&D

addressing individual and organizational processes as they relate to organizational functioning and the measurement of attitudes, perceptions, expectations, and performance of military and civilian Navy personnel in organizational contexts. The human processes are assessed relative to motivation and productivity and new techniques and strategies are developed and applied for improving overall organizational effectiveness. Major program activities include:

1. Identifying and developing appropriate measures and reporting systems of both individual and organizational performance.

2. Investigating the factors and policies that facilitate or inhibit the Navy's organizational functioning.

3. Examining the impact of new technology on workers and organizations and determining what is required to realize expected benefits from the implementation of new technology.

4. Developing principles and techniques for evaluating and enhancing command effectiveness.

6. CHAIR'S SUMMARY

Mr. Crites expressed his appreciation to the Navy Personnel Research and Development Center for hosting the TAG and noted that the efforts of CDR John Kohler, Dr. Robert Blanchard and LT Edward Trautman had contributed to the productivity and cordiality of the meeting. Mr. Crites noted that time constraints have forced some of the SubTAGs to schedule additional, off-line, meetings and that it may be necessary for the subgroups to schedule Monday and/or Friday meetings during TAG week.

Mr. Crites reported that the TAG would be responsive to OUSDR&E's request for information concerning cockpit automation technology. In closing, he thanked the guest speakers, attendees and Ms. Louida D. Murray for their inputs to the meeting.

ATTACHMENT A

AGENDA

DEPARTMENT OF DEFENSE
HUMAN FACTORS ENGINEERING
TECHNICAL ADVISORY GROUP (TAG)
AGENDA - Fifteenth Meeting

5-7 November 1985
Kona Kai Resort, Shelter Island Drive, San Diego, California

Monday, Nov. 4

1900 - 2100	Information Room Open (Subgroup agendas, plenary changes, pre-paid registrations)		324

Tuesday, Nov. 5

0730 - 0825*	Technical Society/Industry Breakfast	Dr. Muckler	Crystal
0800 - 1200	COFFEE, MUFFINS, Registration	Ms. Murray	Lobby
0830 - 0945	HFE Guide to Systems/Equipment	Mr. Heckart	Teak
0830 - 1200	HF Standardization Steering	Mr. Chaikin	Crystal
0830 - 1200	Tri-Service Workload	Ms. Fiedler	Lanai
0830 - 1200	Manned System Modeling	Mr. Hartzell	Surf
1200 - 1330	LUNCHEON BREAK		
1330 - 1625	User-Computer Interaction	Mr. Peterson	Surf
1330 - 1625	Voice-Interactive Systems	Mr. Coler	Teak
1330 - 1625	Test and Evaluation	Mr. Karn	Lanai
1630 - 1730	Army Caucus	Mr. Fry	Lanai
1630 - 1730	Navy Caucus	LCDR Mitchell	Surf
1630 - 1730	Air Force Caucus	Dr. Schiffler	Teak
1630 - 1730	NASA Caucus	Mr. Garren	324
1630 - 1730	TS/I Meeting	Dr. Muckler	Crystal
1830 - 2000	Controls and Displays	Mr. Grossman	Surf
1830 - 2000	Professional Education	Mr. Jones	Crystal
1830 - 2000	LOGSTAG	Mr. Mahar	Teak
2010 - 2100	Operating Board	Mr. Crites	324

*Registration materials (badges, receipts) will be available at the TS/I meeting in the Crystal Room. Coffee and danish will be served during the meeting. Pre-registration and reservations are REQUIRED.

JOINT MEETING IN CONJUNCTION WITH TAG 15:

Sus Ops -- LTC G. Krueger, (301) 427-5521/AV 291-5521.

Aviation Screening -- Dr. M. Sanders, (205) 255-6862/
AV 558-6862

Wednesday, November 6 Bay View Room

0830 - 0900	COFFEE, MUFFINS, Registration	
0900 - 0905	Navy Personnel Research and Development Center Welcome	CDR John Kohler
0905 - 1030	Tutorial: Selecting Performance Measures in HFE Testing and Research	

Moderator: Dr. John Miles, Jr. (USA)
Panelists: LCDR Dennis McBride (USN)
Dr. Frederick Muckler (APA/21)
Dr. James Geddie (USA)
Dr. Stephen Rokicki (USAF)

1030 - 1050	COFFEE	
1050 - 1100	Administrative	
1100 - 1130	Implementation Efforts for MANPRINT	Mr. Judah Katznelson
1130 - 1140	Workload Report	Mr. James Hartzell
1140 - 1150	Manned System Modeling Report	Ms. Heidi Fiedler
1150 - 1200	Professional Education Report	Mr. Todd Jones
1200 - 1330	LUNCHEON BREAK	
1330 - 1430	TBD	TBD
1430 - 1440	Test and Evaluation Report	MR. Keith Karn
1440 - 1450	HFSSC Report	Mr. Gerald Chaikin
1450 - 1500	LOGSTAG Report	Mr. Dale Mahar
1500 - 1515	COFFEE	
1515 - 1545	State of the Art in AI/ES, Decision Aiding and Augmentation for Advanced Military Systems	Dr. Thomas Cook
1545 - 1615	Crew System Ergonomics Information Analysis Center (CSERIAC)	Mr. Steve Heckart
1615 - 1625	HFE-GSED Report	Mr. Steve Heckart
1800 - 1930	Cocktail Party (reservations required)	Teak Room

Thursday, November 7 Bay View Room

0800 - 0830	COFFEE, MUFFINS	
0830 - 0900	Vision in Spatial Disorientation and Loss of Aircraft Attitude or Control Awarness	Col. Grant McNaughton
0900 - 0910	Controls and Displays Report	Mr. Jeffrey Grossman
0910 - 0920	Sustained/Continuous Operations Report	LTC. Gerald Krueger
0920 - 0950	Analysis of Aircraft Avionics Integration	Mr. Cyrus Crites
0950 - 1000	Voice-Interactive Systems Report	Mr. Clay Coler
1000 - 1015	COFFEE	
1015 - 1045	Overview of Navy R&D Efforts at NPRDC	Dr. Robert Blanchard
1045 - 1100	Technical Society/Industry Report	Dr. Frederick Muckler
1100 - 1110	User-Computer Interaction Report	Mr. Larry Peterson
1110 - 1120	Army Report	Mr. Clarence Fry
1120 - 1130	Navy Report	LCDR Thomas Mitchell
1130 - 1140	Air Force Report	Dr. Richard Schiffler
1140 - 1150	NASA Report	Mr. John Garren
1150 - 1200	Chair's Summary	Mr. Cyrus Crites
1200 - 1330	LUNCHEON BREAK	
1330 - 1530	NPRDC Tour	
1345 - 1500	Executive Committee Meeting	324

ATTACHMENT B

TAG OPERATING STRUCTURE

DEPARTMENT OF DEFENSE
HUMAN FACTORS ENGINEERING TECHNICAL ADVISORY GROUP

GOALS

Provide a mechanism for exchange of technical information in the development and application of human factors engineering.

Enhance working-level coordination among Government agencies involved in HFE technology research, development, and application.

Identify human factors engineering technical issues and technology gaps.

Encourage and sponsor in-depth technical interaction, including subgroups as required in selected topical areas.

Assist as required in the preparation and coordination of triservice documents such as Technology Coordinating Papers and Topical Reviews.

SCOPE

Because of the diversity of subject matter covered by the HFE discipline, the scope of technical areas addressed by the Technical Advisory Group (TAG) is necessarily broad. In general, HFE, as defined for purposes of TAG operation, deals with concepts, data, methodologies, and procedures which are relevant to the development, operation, and maintenance of hardware and software systems. Subject matter subsumes all technologies aimed at understanding and defining the capabilities of human operators and maintainers and insuring the integration of the human component into the total system to enhance systems effectiveness. Technologies directed toward improved manpower utilization through selection, classification, and training are included as appropriate.

TOPICAL AREAS

The TAG will address research and technologies designed to impact man-machine system development and operation throughout the complete system life-cycle. The general topics of concern to the TAG include, but are not limited to:

a. Procedures for use by HFE specialists, systems analysts, and design engineers involved in the provision of HFE support during system development or modification.

b. Methodologies oriented toward the identification and solution of operator/maintainer problems related to equipment design, operation, and cost/effectiveness.

c. Mechanisms for application of developed HFE technologies, including formal and informal approaches to validation and implementation, and the determination of time windows for application.

GROUP COMPOSITION

The TAG will consist of technical representatives from Government agencies with research and development responsibility in the topical areas specified above. Additional representatives from activities with allied interests may affiliate with the TAG as appropriate. Attendance at specific meetings may be augmented by technical experts in special topical areas.

OPERATING BOARD

The TAG Operating Board is responsible for the conduct of TAG business and the implementation of TAG policies. The Board consists of an Executive Committee, the chairpersons of all SubTAGs and Committees, and liaison representatives from selected Government agencies. Operating Board meetings are called at the discretion of the TAG Chair.

The Executive Committee will be responsible for providing required continuity and acting for the full TAG between regular meetings. Regular members of the Executive Committee will be:

- o Current Chair
- o Immediate Past Chair
- o Chair Select
- o Army Representative
- o Navy Representative
- o Air Force Representative
- o NASA Representative

CONDUCT OF BUSINESS

Meetings of the TAG will be held semi-annually, in the Spring and the Fall. Chairing of the group will rotate annually among the Army, Navy, and the Air Force. The Chair Select will be chosen by a caucus of the service, whose turn it is to chair the DOD HFE TAG. Advice and counsel will be provided by the Operating Board. The Service Representatives will be selected by service caucus at the Spring meetings in even-numbered calendar years. Advice and counsel will be provided by the Operating Board. Minutes of each meeting will be compiled by the Chair. Minutes will be distributed to all participants, to appropriate OSD offices, and to other agreed-upon agencies. Minutes shall serve as the principal mechanism for the reporting of group activity. A file of minutes and relevant correspondence shall be maintained by each Chair. This file shall be passed to the succeeding Chair together with any additions to the file.

TAG SUBGROUPS

The DOD HFE TAG sactions two categories of subgroups: SubTAGs and Committees. Such groups will be sponsored by the TAG as appropriate to respond to needs for more detailed interchange and coordination in specific technical areas. SubTAGs will address problems of a general or continuing nature within a specific field of technology and are to develop their own working charters and operating procedures. SubTAGs may be disestablished upon recommendation of the Executive Committee. Committees will serve at the pleasure of the Operating Board and will address specifically defined tasks or problems. These committees will be disestablished on completion of those tasks or upon recommendation of the Executive Committee. Reports from each subgroup will be published separately and included as a regular item of business on each TAG meeting agenda. Current subgroups are identified in Appendix A.

ATTACHMENT C

TAG POLICIES

TAG POLICIES

1. Membership (General membership policies are outlined in the Operating Structure, under "Group Composition.")

1.1 Individuals who are not affiliated with Government agencies but are associated with technical societies or industrial associations with a stated interest in human factors engineering are to submit a letter on the organization's letterhead, confirming their status as the organization's representative, to the current chairperson of the Technical Society/Industry Committee.

2. Meeting Sites (Sites are selected by the Executive Committee with a view toward a balance in geographic location, service hosting the meeting, and meeting facilities.)

2.1 Tag members are encouraged to recommend potential meeting sites.

2.2 Organizations who wish to host the TAG should contact their Service Representative or the current TAG Chair.

3. Agenda (The agenda is determined approximately two months before the scheduled meeting. The Executive Committee selects the topics from those recommended by the Service Representatives and the current TAG Chair.)

3.1 TAG members are encouraged to suggest potential agenda topics or topics suitable for tutorial sessions to their Service Representative or to the current TAG Chair.

4. Registration (Registration fees and the date of the close of registration are announced in an information letter sent approximately one month before the scheduled meeting.)

4.1 All attendees are expected to pre-register and prepay by mail.

4.2 Individuals receiving late travel approvals may pre-register by phone by contacting the TAG Coordinator identified in the TAG invitation letter. All payments made at the meeting site are to be in cash.

5. Minutes (The Minutes of each meeting serve as the principal mechanism for the reporting of TAG activities. The Minutes are published as a draft document and distributed to attendees and other selected agencies approximately three months after the meeting.)

5.1 Individuals or agencies desiring to be included on the distribution list for a specific meeting should contact the TAG Coordinator.

5.2 Amendments to the Minutes are to be made to the TAG Chair in writing prior to the succeeding meeting.

5.3 Presentors are expected to submit a copy of their presentations and hardcopies of their visual materials to the TAG Coordinator for inclusion in the Minutes.

6. Subgroups (See the Operating Structure, section entitled "TAG Subgroups," for specific information regarding the purposes and operating procedures of SubTAGs and Committees.)

6.1 All subgroups are strongly encouraged to meet in conjunction with the TAG at least once each calendar year.

6.2 All subgroups meeting in conjunction with the TAG are required to provide a chairperson for the specific subgroup meeting.

6.3 All subgroup chairpersons are encouraged to submit a brief report of each meeting to be included in the set of TAG Minutes covering the subgroup meeting timeframe.

6.4 All subgroups are required to provide the TAG Coordinator with an up-to-date list of their membership, for use in the distribution of TAG announcements.

6.5 All SubTAGs are required to submit to the Executive Committee a Charter including, but not limited to, statements regarding:

- o objectives
- o scope
- o membership policies
- o chairperson
- o meeting schedule

6.6 Committees are required to submit to the Executive Committee a document including, but not limited to, brief statements regarding:

- o objectives
- o membership policies
- o chairperson

7. Subgroup Establishment

7.1 Groups interested in addressing technical areas not covered by existing subgroups may request the TAG Chair to provide subgroup agenda meeting time.

7.2 Formal subgroups may be established by recommendation of the Executive Committee.

8. Chair/Representative Selection (General selection procedures are outlined in the Operating Structure under "Conduct of Business.")

8.1 A Service caucus may be called by the TAG Chair or the current Service Representative.

8.2 Methods of determining the Chair Select and Service Representatives are Service peculiar.

8.3 Unexpired terms of office will be filled by appointment by the Executive Committee, until a caucus of the Service can be called at the next regularly scheduled meeting.

9. Funding The funding required for the organization, conduct, and documentation of all TAG meetings shall be done jointly be the three services. The specific mechanisms to obtain and allocate funding from services shall be arranged by the Current Chair, Chair Select and Immediate Past Chair.

10. Policy Changes

10.1 Additions to or amendments of the above policies may be recommended by submitting the suggested change(s) in writing to the TAG Chair.

10.2 Policies may be amended by a majority vote of those Operating Board members in attendance at the Operating Board meeting in which amendments have been proposed.

ATTACHMENT D

TAG OPERATING BOARD

TAG OPERATING BOARD
(1/15/86)

Executive Committee

Current Chair (Air Force)
Mr. Cyrus D. Crites
6520 TEST-ENAH
Stop 239
Edwards AFB, CA 93523
(805) 277-3334
AV 350-3334

Immediate Past Chair (Navy)
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Navy Seat
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(202) 696-4502
AV 226-4502

Chair Select (Army)
Dr. Michael H. Strub
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(915) 568-4491
AV 978-5297

Army Representative
Mr. Clarence Fry
Director, USA Lab Command
Human Engineering Lab; SLCHE-AD
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ATTACHMENT E.1

CORRESPONDENCE

DONALD I. CARTER

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

RESEARCH AND
ENGINEERING
(R&AT)

22 OCT 1985

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY
(RESEARCH, DEVELOPMENT AND ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, ENGINEERING AND SYSTEMS)
ASSISTANT SECRETARY OF THE AIR FORCE
(RESEARCH, DEVELOPMENT AND LOGISTICS)

SUBJECT: Department of Defense Human Factors Engineering Technical Advisory Group (DoD HFE TAG)

I am pleased at the response of the Services to the DoD and Congressional guidance on implementing the DoD HFE TAG. The HFE TAG was implemented by a Memorandum of Understanding signed by the Assistant Secretaries of the Services in November 1976. The TAG, in its nearly nine years of existence, has been a productive vehicle for exchanging technical data and coordinating research of the DoD laboratories, the National Aeronautics and Space Administration, and the Federal Aviation Administration. Examples of concrete results attained by the HFE TAG include:

o Inter-Service coordination in the following HFE technical areas:

- Controls and Displays
- Aviation Personnel Screening and Prediction
- Logistics
- Test and Evaluation
- Manned System Modeling
- Standardization
- Workload
- User-Computer Interaction
- Voice Interactive Systems
- Technical Society/Industry Liaison
- Sustained/Continuous Operations

o The development of an HFE practitioner training course implemented by all military Services.

o The cooperative compilation and dissemination of research pertinent to the hardware and system design process.

o The regular review and update of military specifications, standards and design documents by the services and industry.

I encourage the Services to continue their vigorous support of the HFE TAG and other similar inter-Service research coordinating groups.

Please convey our gratitude through the present Service coordinators for the HFE TAG.

Army: Dr. Michael Strub, Army Research Institute for the Behavioral and Social Sciences

Mr. Clarence Fry, U.S. Army Human Engineering Laboratory

Navy: Dr. John O'Hare, Office of Naval Research
LCDR Thomas M. Mitchell, Pacific Missile Test Center

Air Force: Mr. Cy Crites, Present Chairman, Edwards Flight Test Center

Dr. Richard Schiffler, Aeronautical Systems Division

Donald I. Carter
Acting Deputy Under Secretary
(Research and Advanced Technology)

ATTACHMENT E.2

CORRESPONDENCE

CAPT PAUL CHATELIER

COCKPIT AUTOMATION TECHNOLOGY PROJECT
REQUEST FOR ASSISTANCE FROM HFE TAG

REQUEST (Paul Chatelier)

I WOULD APPRECIATE THE HELP OF THE TAG AND/OR ONE OR MORE OF ITS SUB-TAGS IN OBTAINING SOME BACKGROUND INFORMATION ON HUMAN FACTORS RESEARCH WHICH MAY HAVE AN IMPACT OF COCKPIT AUTOMATION TECHNOLOGY. THE INFORMATION COULD COME AS ANSWERS TO THE FOLLOWING GENERAL QUESTIONS WHICH ARE LISTED IN ORDER OF PRIORITY.

1. WHAT R + D PROJECTS ARE UNDER WAY WHICH ARE RELEVANT TO THE DEVELOPMENT AND DESIGN OF COCKPIT AUTOMATION? WHAT I NEED IS A LIST OF TASKS AND PROJECTS BY PROGRAM ELEMENT. IN ADDITION, POINTS OF CONTACT FOR FOLLOW - UP QUESTIONS WOULD BE VERY HELPFUL.

2. FROM THE HUMAN FACTORS PERSPECTIVE WHAT ARE THE ISSUES, WHAT ARE THE NON ISSUES. I.E. WHAT DO WE KNOW, WHAT DON'T WE KNOW THAT IS RELEVANT TO THE DEVELOPMENT AND DESIGN OF COCKPIT AUTOMATION. FOR EXAMPLE, HAVE WE MADE SIGNIFICANT PROGRESS OVER THE PAST FEW YEARS IN DEVELOPING WAYS TO ALLOCATE FUNCTIONS BETWEEN CREWMEMBER AND MACHINE. ARE ANY NEW SPECIFICATIONS AVAILABLE OR EMERGING ON WHEN AND HOW MUCH TO AID HUMAN DECISION MAKING? HERE, I WOULD LIKE TO OBTAIN A LIST OF ISSUES/ NON ISSUES AND RELATED SUMMARIES OF R + D PROGRESS.

3. WHAT THOUGHTS, OR INSIGHTS DOES THE TAG HAVE ABOUT THE TRADE-OFF BETWEEN TRAINING AND AUTOMATION?

TO BE FULLY HELPFUL, THE INFORMATION WOULD NEED TO BE AVAILABLE BY THE FIRST WEEK IN JANUARY 1986.

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BACKGROUND

In April 1985, a topical review on Cockpit Automation Technology was held at the request of the Deputy Under Secretary of Defense for Research and Advanced Technology. The review drew 84 people from nine organizations. The purpose of the review was to exchange information and identify opportunities for future development.

A number of conclusions emerged from two days of presentations and discussions. These are summarized in Attachment 2. The major conclusion, however, called for the preparation of coordinated, inter-service policy and plans for cockpit automation technology R &D. In response to that conclusion the Deputy Under Secretary asked the Service Secretaries for Research to task their JDL to undertake the recommended planning (Attachment 1). The JDL are being asked to provide draft plans by January, 1986, and a final statement by April. I may be called upon to provide some assistance and would like to have enough background information to do so.

SOME SUGGESTIONS FOR WHAT TO INCLUDE IN THE INFORMATION

Question 1. A listing of current R + D tasks or work unit by Program Element and Project Number, with a very brief description of the effort would be helpful.

Question 2. Conclusions and recommendations from a 1982 report entitled "Automation in Combat Aircraft", National Academy Press, Washington, D.C., might provide a useful point of departure in addressing this question. I've provided a list of those conclusions and recommendations in Attachment 3. For example, are the issues implicit in that list still valid. Has their importance - as problems - diminished because of progress in human factors or engineering technology? Has it increased because of side effects or led to new issues? The list is not meant to be constraining but rather is an illustrative point of departure.

Questions 3 and 4 are open-ended. Any suggestions, ideas or information would be helpful.

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OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON DC 20301

RESEARCH AND
ENGINEERING

16 SEP 1985

(R&AT)

MEMORANDUM FOR DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECT AGENCY

SUBJECT: Combat Aircraft Cockpit Automation Technology

Enclosed is a summary report on the DoD/NASA Topical Review of Combat Aircraft Cockpit Automation technology held 24-25 April 1985 at the Naval Air Development Center, Warminster, Pennsylvania. Enclosed also is a memorandum I have sent to Assistant Secretaries of the three Services requesting their support of a joint, continuing coordination function in this field, to implement a major recommendation of the report.

Because DARPA is intimately concerned with this general area of research and technology, it is vital to the success of the planning activities that you participate in them. It would be appreciated if you would inform Mr. Raymond F. Siewert, my staff point of contact, telephone 697-7922, of your designee. Thank you for your cooperation.

Donald I. Carter
Acting Deputy Under Secretary
(Research and Advanced Technology)

Enclosures (2)
a/s

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

RESEARCH AND
ENGINEERING

(R&AT)

16 SEP 1985

Dr. Raymond Colladay
Associate Administrator for Aeronautics
and Space Technology
National Aeronautics and Space Administration
Washington, DC 20546

Dear Dr. Colladay:

Enclosed is a summary report on the DoD/NASA Topical Review of Combat Aircraft Cockpit Automation technology held 24-25 April 1985 at the Naval Air Development Center, Warminster, Pennsylvania. Enclosed also is a memorandum I have sent to Assistant Secretaries of the three Services requesting their support of a joint, continuing coordination function in this field, to implement a major recommendation of the report.

Because NASA's research and technology in many of the fundamental disciplines and in system integration are importantly related to our objectives, I invite NASA's participation in planning and implementing the coordination we desire. To assist us, it would be helpful if you would designate a knowledgeable, senior member of your staff to work with us, and notify Mr. Raymond F. Siewert, my staff point of contact. He can be reached at telephone number 697-7922.

Sincerely,

Donald I. Carter
Acting Deputy Under Secretary
(Research and Advanced Technology)

Enclosures (2)
a/s

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

RESEARCH AND ENGINEERING

16 SEP 1985

(R&AT)

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (RESEARCH, DEVELOPMENT AND ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY (RESEARCH, ENGINEERING AND SYSTEMS)
ASSISTANT SECRETARY OF THE AIR FORCE (RESEARCH, DEVELOPMENT AND LOGISTICS)

SUBJECT: Combat Aircraft Cockpit Automation Technology

Enclosed is a summary report on a Topical Review of combat aircraft cockpit automation technology held 24-25 April 1985 at the Naval Air Development Center, Warminster, Pennsylvania. All three Services, DARPA and NASA participated in the review.

The primary objectives were to provide a broad exchange of information rather than technology details, and to provide a forum to discuss issues common to all the Services as they move toward increased automation in combat aircraft. All the conclusions and recommendations in the report should be of interest to you, but I want to draw your attention specifically to the final recommendation, which is that coordinated plans should be provided for developing the basic technologies and system design methodologies.

The importance of this recommendation suggests to me that it should be implemented through the Joint Directors of Laboratories, with participation by each of the Services, DARPA and NASA. Accordingly, I request that the JDL be tasked to produce a coordinated technology development plan as well as a plan for tracking and coordinating its execution. It is requested that both plans be provided within six months of this date, with a status report at mid-point.

I have asked Mr. Raymond F. Siewert, Director of my Military Systems Technology Office, to be the principal point of contact for this task in my office. He is available to clarify any questions that may arise and to assist the JDL in the timely development of the plans. His telephone number is (202) 697-7922.

Donald I. Carter
Acting Deputy Under Secretary
(Research and Advanced Technology)

Enclosure

SUMMARY REPORT: TOPICAL REVIEW
OF COMBAT AIRCRAFT COCKPIT
AUTOMATION TECHNOLOGY

I. INTRODUCTION

A Topical Review of Combat Aircraft Cockpit Automation (CACA) technology took place on April 24-25, 1985 at the Naval Air Development Center, Warminster, Pennsylvania. More than eighty persons, largely from the Military Services, Defense Agencies and NASA (see enclosure 1) participated in the Review.

A Topical Review of this area had been requested by the Deputy Under Secretary of Defense, Research and Engineering (Research and Advanced Technology) because of its increasing importance and technical sophistication, and due to the rapidity with which each of the Services is proceeding, generally independently.

The primary objective of the Review was information exchange and identification of issues and opportunities. Accordingly, most program presentations and discussions of issues were largely summary in nature, and neither the technical nor programmatic details were covered in depth. The first day of the Review (see agenda, enclosure 2) was devoted to presentations by all participating organizations, and the second day was spent on a series of panel discussions with audience participation. During preparatory meetings, each Panel formulated an Issue Paper to focus its views. These Issue Papers are available on request to the Office of Military Systems Technology, OUSDRE(R&AT).

The Findings and Conclusions, and Recommendations from this Topical Review are contained in Sections II and III of this Summary Report. Overall, it is believed that the Review successfully achieved its objectives and was considered valuable by most participants and attendees.

II. FINDINGS AND CONCLUSIONS

These findings and conclusions reflect views of a group of CACA Steering Group members (or their designees) and several Panel Chairmen.

1. Cockpit automation is an intensively interdisciplinary field, but research activities in many areas are not well coordinated.

Combat aircraft cockpit design integrates the entire weapon system and includes all technologies related to aircraft and weapon subsystem functions and crew/machine interfaces. It also includes disciplines concerned with human physical and mental capabilities and limitations, and the emerging disciplines related to expert systems and machine (artificial) intelligence applications to combat aircraft missions and survival. Although research is proceeding in most of these areas, the Topical Review did not reveal any overall coordination, plans or roadmaps for cockpit automation research and technology development and transition.

2. Standards and methods for cockpit design are lacking today, and current practices are "bottom-up" rather than "top-down."

The design approach for each new aircraft cockpit (that is, for total system integration, control and management) has become quite complicated and time-consuming. It is performed primarily in an ad hoc manner in every new situation and is more heavily influenced by dominant personal views, experience and personality factors than by established criteria or procedures. Each new aircraft cockpit system, faced with new requirements to be accommodated and new technologies to be incorporated, evolves largely through a trial-and-error, "bottom-up" rather than "top-down" process, without an established set of criteria and integration principles. While this fact may reflect the newness and rapid evolution of requirements and technology, it also suggests the need for maturation to capitalize both on both experience and broad systems analysis.

3. The future role of man in the combat aircraft cockpit is not well defined.

Cockpit automation (transferring functions once performed by humans to the machine) is justified to the degree it can improve the probability of increased mission effectiveness or survivability. Aircrews presently provide essential system capabilities involving comprehension, reasoning and evaluation, knowledge, skill, "judgment" and decision making, as well as overall system management. But as technologies advance in avionic and computer-based disciplines, including expert systems and machine intelligence, some (perhaps many) of those human capabilities may become future candidates for automation.

While the optimal role of man and his relationship to the rest of a system incorporating those future technological advances is at the moment unclear, most conferees believed that man should somehow remain "in charge". How this arrangement was to be accomplished remained undecided. Most agreed that human

capabilities involving imagination, intuition and innovation should remain available, and that man must have a "last word" or ultimate decision and override capability, particularly in unusual and emergency situations where "judgment" should be exercised. Man should have the option of breaking the rules or exceeding allowable machine-set limits, even in apparent contradiction to his self interest, and of making "illogical" or "wrong" decisions if his experience or intuition should indicate that such desperate actions might be preferred choices.

Notwithstanding, it was agreed that in the future man can't do it all: that the situation will be too complex, fast moving and incomprehensible for man alone. Therefore, it was evident that a new symbiotic relationship between man and intelligent machine, not yet defined, will have to evolve.

4. Appropriate measures of effectiveness will be needed to help guide future automation choices and decisions for combat aircraft.

Before correct choices can be made on future cockpit automation, better techniques will be needed to anticipate and assess their actual effects and utility. Criteria for performance and effectiveness evaluation have not been established except perhaps in a philosophical sense. More specific criteria must be developed concurrently with the development of the new technologies to which they will be applied, as well as valid means for anticipating and assessing the effect and utility of any proposed new automation.

III. RECOMMENDATIONS

1. The development of critical technologies should be continued.

Research in each area critical to the development of future combat aircraft cockpit automation technology should proceed with high priority in each user service and contributing research organization. One such area includes all aspects of the man/machine interface for better communication and interaction, including additional research on voice recognition/interaction. A second area includes expert systems and machine intelligence based on advances in every area of computer science, including "knowledge engineering" to organize, correlate, and make information bases accessible in a dynamic environment. Another critical area for research is that of human characteristics, capabilities and limitations in the combat aircraft environment.

2. A mature, systems approach to combat aircraft cockpit design and integration should be developed.

The time has come when the complexity of the task demands a systems approach instead of a "bottom-up", trial-and-error, personality-dominated approach. Deriving maximum benefits from both human and machine characteristics is virtually impossible otherwise, and the penalties for failing to deal with the whole set of requirements and available technologies as a system would include wasted time and expense, undesirable compromise of capabilities, and great difficulties (perhaps impossibilities) in introducing necessary corrections or desirable improvements downstream. Interdisciplinary in nature, the development of system design methodologies and design aids should reflect the expertise of organizations familiar with large, complex systems.

3. The optimal role of man in a new man-intelligent machine symbiosis must be established.

A total systems approach for highly automated future combat aircraft design integration is needed to establish the optimal role of man. The degree and circumstances for his management of information, decision making, supervision and control must be established when there are counterpart machine capabilities available. Situationally dependent and override options for every phase of the mission need resolution to preserve maximum desirable flexibility.

4. Coordinated plans should be provided for developing the basic technologies and system design methodologies for future combat aircraft cockpit design and integration.

The magnitude and importance of the subject, the uneven evolution of the underlying technologies, and the requirements for a systems approach to methodology indicate the need for greater coordination and overall planning of research and transition opportunities. No conclusion was reached on how this might best be accomplished. Options include coordination at the Joint Directors of Laboratories level, or within the Office of the Secretary of Defense, or by an ad hoc interorganizational group appointed to work toward common goals. An important requirement of any coordinating group is that the constituent members be influential within their own organizations. Another important requirement is that the coordination group include combat pilots and crew whose experience and insights are invaluable.

AGENDA

TOPICAL REVIEW, DOD and NASA, on
COMBAT AIRCRAFT COCKPIT AUTOMATION

NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA.
24,25 APRIL 1985

WEDNESDAY, APRIL 24 1985

0830	Welcome	CAPT G.F.Wright Chief Staff Officer NAVAIRDEVCEN
0835	Introductory Remarks	Mr. Raymond F. Siewert OUSDRE
0845	Combat Aircraft Scenarios (Circa Year 2000)	
	Army	Dr. Lew Feaster AVSCOM
	Navy	CDR Barry Dysart OPNAV
	Air Force	Mr. Phil Kulwicki AFAMRL
1000	Ongoing Programs	
	Navy	
	F-18 Cockpit Design	CDR Bill Moroney NAVAIRDEVCEN
	Man-Machine Information Transfer	Mr. Bill King NAVAIR
	Army	
	Advanced Rotorcraft Tech.Integ.(ARTI)	Mr.John Macrino ATL
1200	Lunch	
1300	Ongoing Programs(Cont)	
	Air Force	
	Cockpit Automation Tech.(CAT) Program	MAJ Dean Cole AFAMD
	AFTI/F-16 AMAS	LTCOL Don Ross AFWAL
	DARPA	
	Pilots Associate	LTCOL John Retelle TTO
	NASA	
	Aerospace Human Factors Research	Dr. Melvin Montemerlo OAST
1650	General Discussion	
1700	Adjourn First Day	

THURSDAY, APRIL 25,1985

0830 Introductory Remarks - Mr. Raymond Siewert, OUSDRE

0845 Panel Presentations/Discussions

Panel 1 COCKPIT AUTOMATION DESIGN DECISIONS
How are they made and validated?

COL Mike McNaughton, AFAMD (Chairman)
Mr. Samuel Morello, NASA/LaRC
Dr. Norm Warner, NAVAIRDEVCEN
Mr. John Macrino,ATL

Panel 2 HUMAN CHARACTERISTICS
How are they accounted for in cockpit design?

Dr. Genevieve Hadded, AFSC (Chairman)
CDR Thomas Jones, NAVAIR
Mr. Jim Voorhees, AL/ARC
Dr. Ed Huff, NASA/ARC

Panel 3 ARTIFICIAL INTELLIGENCE
What does it offer for combat aircraft?

Mr. Larry Ott, NAVAIRDEVCEN (Chairman)
Ms. Kathy Abbott, NASA/LaRC
Mr. Alfred Klieder, ARO
Dr. Don Moon, AFWAL
LTCOL John Retelle, DARPA

1200 Lunch

1300 Panel 4 SYSTEM DESIGN AND INTEGRATION
How will systems incorporating both man and machine intelligence be designed?

Mr. Bill Mulley, NAVAIRDEVCEN (Chairman)
Mr. Ray Clark, ARDA
Dr. David Nagel, NASA/ARC
Dr. John Reising, AFWAL

Panel 5 HARDWARE
Are there new requirements?

Mr. Thomas House, ATL (Chairman)
Dr. Anthoney DeThomas, AFWAL
Mr. Jack Hatfield, NASA/LaRC
Mr. Bill King, NAVAIR

1515 General Discussion and Summary

1615 Adjourn Topical Review

Attendance Breakdown

Topical Review of Combat Aircraft Cockpit Automation Technology

at NAVAIRDEVCEN, Warminster, PA, April 24-25, 1985

ORGANIZATION	ATTENDANCE
Office of the Secretary of Defense	3
Defense Advanced Research Projects Agency	1
General Accounting Office	1
Defense Intelligence Agency	1
National Bureau of Standards	1
National Aeronautics and Space Administration	9
United States Army	11
United States Navy	37
United States Air Force	20
Total Attendance:	84

Automation in Combat Aircraft

Committee on Automation in Combat Aircraft
Air Force Studies Board
Assembly of Engineering
National Research Council

National Academy Press
Washington, D.C. 1982

E-2.13

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competencies and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to the procedures approved by the Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

This report represents work under Contract No. F49620-79-C-0094 between the United States Air Force and the National Academy of Sciences.

Available from:

Air Force Studies Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

This report is concerned with the automation of combat aircraft to support the mission of the United States Air Force. According to the statement of task decided upon by the Air Force and the National Research Council, this study addresses the issue in terms of manned systems. Given the limited time available for the study, the Committee on Automation of Combat Aircraft concentrated on single-seat fighters.

The term "automation" is subject to diverse interpretations. It has been used variously to describe the control of a single function by a simple on-off mechanism, as in the thermostatic control of building temperatures. It has been used to describe the concurrent display of data from various sources to a person for interpretation: an example is the cockpit displays of a modern fighter aircraft, which combine information, for instance, from a radar and an electro-optical sensor with computer-derived flight parameters. Automation has also been used to describe the control of complex processes, in which the automated system replaces some human monitoring, decisionmaking, and/or motor functions, as in automatic flight control.

In this study, the committee defined automation as those processes by which essential functions can be performed with partial, intermittent, or no intervention by the pilot. In this report, the term automation will describe any effort to move the cognitive processes of flying the aircraft and managing its weapons from the pilot or aircrew to a computer-dominated system.

Human Limitations in the Combat Environment

Technological advances in the past two decades have made possible the development of complex and more competent aircraft that can fly under more difficult conditions (such as close to the ground, at night, or underneath the weather), and at faster speeds. They can also perform more complex missions, such as simultaneously attacking multiple targets.

At the same time, and perhaps as a consequence of these technological advances, the environment in which aircraft must fly and fight has become more dangerous. Threats from the air and ground are faster moving and harder to detect. Not only are the aircraft vulnerable to enemy attack, but they can also be shot down accidentally by U.S. surface-to-air missiles.

The only element that has not changed significantly over the years is the human operator. The pilot is limited in his ability to assimilate and perform tasks. He may not be able to handle the increased workload involved in operating today's faster, more highly mechanized aircraft. Limitations in human capabilities are difficult to overcome, and as yet have not been completely described. The proper use of automation in aircraft could help to overcome these limitations.

In fact, both the military and commercial aviation communities have been using automation to various degrees over the years. Extensive automation has been used in manned vehicles such as the Space Shuttle. Air Force aircraft such as the F-106, F/FB-111, and others are also capable of semi-automated flight. Yet automation presents its own difficulties, in terms of cost, reliability, maintenance, and complexity of operation. To reduce cost and complexity, and because of technology limitations, the most recent Air Force aircraft (F-15, F-16, and A-10) have been designed with only selected automated features, to perform essential functions. These aircraft can be considered semi-automated at best.

Operating these high-performance aircraft (the F-15, F-16, and A-10) places great demands on the pilot. The increased workload that results from the complexity of the aircraft and the challenge of today's combat situation may lead to errors or mission failure.

This workload is especially evident in the cockpit. Recent advances in avionics and weapons technology have led to an exponential increase in the numbers of cockpit displays and controls since the 1920s. Through these displays, the pilot is given large quantities of information in rapid succession. He needs to be aware of the aircraft's internal and external situation, in addition to operating the fire-control system, selecting and firing munitions, and positioning a large number of switches. When the pilot focuses his attention on a particularly demanding function, such as locking onto an enemy target or following rugged, hilly terrain, he may lose track of others, even when provided with some automated functions (such as weight distribution, fuel-flow management, flight-attitude control, and threat warning).

In the past, when missions and aircraft were simpler, the pilot was able to assess the current situation and draw on past experience in executing his mission. If the trend toward complexity of aircraft and combat situations continues, the pilot will be increasingly unable to perform his mission without extensive aid.

By the 1990s, combat aircraft could be more fully automated to aid and support the pilot in performing his tasks and keeping track of the overall situation, thereby increasing the probability that the mission will succeed and the pilot and aircraft will survive.

If automation is truly to improve mission performance, aircraft designers must carefully consider where automation would best serve pilots' needs. They must examine not only the technology, but the human factors involved. This will require an understanding of how pilots process and assimilate information and how they think about their tasks, as well as an understanding of the performance characteristics of the controls and displays through which the pilot and the automated systems interact.

New Opportunities for Automation

The committee believes that new Air Force development and application of automated features based on computer technology can improve the operational effectiveness of combat aircraft. In addition, it will enhance the chances of survival for both the aircraft and the pilot. The reliability and capacities of computers are increasing. At the same time, size, weight, and cost per unit of computer power is decreasing enough to justify its extensive use to provide a comprehensive, integrated, up-to-the-minute model of the aircraft and its mission. Also, since software costs are dominating hardware costs, it makes economic sense to design systems with flexibility to accommodate new requirements and developments over the operational life of the aircraft.

Acceptance of Automation

Air Force personnel are generally receptive to further automation of combat aircraft. Although senior managers appreciate the potential of automation, they are not oversold on its merits. Because of their concern about increased cost and complexity of automated systems, and the possibility of low reliability, managers are conservative in making commitments to the increased use of automated systems.

The aircrews exhibit similar attitudes, with a strong "show me" tone. Pilots wish to retain the ability to select automated functions and to intervene in their operation. Aircrews want simplicity in execution as well as performance. They accept automation of functions that humans cannot perform adequately, functions that distract pilots from critical tasks, and functions or routines that are infrequently performed and can be done more reliably through automation.

Emphasis in the development of automated systems has been on data and information displays and on sensors--the "outer" ends of aircraft automation. The "inner" part of the problems--processing these inputs from diverse information sources to improve pilot awareness of the outside world and the status of his aircraft--is just beginning to receive needed attention.

Several current programs are developing technology that can help to identify the operational approach to and need for automation. These programs include the Advanced Fighter Technology Integrator/ Advanced Maneuvering Attack Systems (AFTI-16/AMAS) program, the Low Altitude Navigation Targeting Infrared for Night (LANTIRN) program, and development of terrain following and terrain avoidance (TF/TA) technology. (See the Glossary for definitions of these programs.) The prototypes developed in these programs can contribute to understanding, and perhaps to satisfying, the operational community's immediate stated need for improved capabilities to fly low, at night, and during severe weather, using terrain for cover. The long-range goal is the ability to fly missions effectively in all types of weather, in the daytime and at night, devastating the enemy and surviving in hostile environments. To realize this goal, more complete forms of automation that do not detract from aircraft availability (because of "downtime" or problems with reliability) will be necessary.

Questions of Reliability

The availability of combat aircraft is a central concern. It depends on the reliability of the aircraft and their subsystems, and on the adequacy of maintenance and logistics. It is reasonably clear that reliability would be improved if these subsystems were subjected to follow-on cycles of modification after feasibility demonstration and testing.

The committee has not examined the problem of unreliability in enough depth to ascertain its actual causes, but inadequacies in testing, design margins, packaging, vibration isolation, and temperature control, along with excessive handling, appear to be sources of trouble. Developers of electronic systems for both commercial aircraft and strategic missiles have concentrated on these items in their programs to attain high reliability. We do know that environmental factors greatly influence the reliability of aircraft equipment, and that a tactical aircraft is exposed to far more hostile conditions than a commercial aircraft or a missile in a silo. These conditions include frequent power on-off cycles, short but intense sorties, and inexperienced maintenance crews.

Addressing some of these problems will help to improve aircraft reliability, especially if combined with designs that provide redundancy of components and fault isolation and detection. In addition, an overall systems architecture for the aircraft that allows the integration of various components and accommodates new developments will be of great benefit in developing reliable aircraft. Finally, pilots demand provisions to intervene in the case of subsystem failure.

The Need for Integrated Systems

Technology is available for developing suitable automation for combat aircraft of the 1990s, and to modify some existing aircraft and some now in production. To achieve this goal, the Air Force will have to define the requirements for automation, and recognize that the task requires an integrated systems approach, rather than a collection of piecemeal efforts. For such an integrated approach, a focal point for automation should be established. Flight trajectory and attitude control should be the focal point for all aircraft automation. This function--the maintenance of the correct flight trajectory and attitude, or orientation of the plan, over time--is the heart, mind, and nerves of the aircraft, to which all other functions are keyed. Therefore, it can form the core of a truly integrated system of automated features.

A flexible architecture for flight trajectory and attitude control is vital: logical partitioning and standard interfaces will be necessary to permit the later addition of sensors and weapons for more highly developed systems. This is a prudent way to accommodate change in a fleet of aircraft that will remain in use for a long time. Correct core design can lead to standardized software and hardware applicable to more than one airplane. A deliberate systems-oriented approach is essential to avoid a proliferation of incompatible functions, controls, and displays. A basic model should be developed for the architectural design. This model should include, at the least, the specifications of cockpit features, flight- and engine-control systems, and navigation elements.

A comprehensive, thorough, adequately supported testing and evaluation program must be a major element of any such development. The operational and engineering flight-test communities should be involved. If effective automated systems are to be available in the 1990s, now is the time to start.

A Note on Safety

This study group's discussions with military pilots lead it to conclude that flying high-performance aircraft is hazardous, and is likely to be more so in the future. During the course of this study, the group received information on certain safety-related technologies and systems that will affect future Air Force research and development (R&D). While these technologies and systems are not strictly within the scope of the study, they are of such importance that comments are appropriate.

Identification, Friend, Foe, or Neutral

A longstanding problem that still has no clear solution is the identification of friends, foes, and neutral forces, abbreviated IFFN. Reliable means of identifying friendly, as well as enemy, forces are vital. The combat arena of the future will be even faster moving than that of today and will be filled with intense activity. If identifications must be made visually by pilots, a significant tactical advantage of long-range detection sensors and long-range weapons will be lost. The development and use of reliable equipment for the identification of friendly, hostile, or neutral forces is crucial to increasing combat effectiveness and the chances of survival. One possible solution may involve the coupling of several sensors and systems to supply intelligence and positional information, as well as information on the situation external to the aircraft.

The problems of target assignment and acquisition go along with that of identification. Once identification is made, the next problem is the efficient use of the force to attack multiple targets. When there are multiple targets, it is helpful to have a system for exchanging information among individual aircraft to ensure that each plane attacks a different target. Such a target-assignment process would make more effective use of the fighting force and would also improve the pilots' general awareness of combat situations. Such a process is possible through the use of systems such as the multiple-access digital data link known as the Joint Tactical Information Distribution System (JTIDS). This and similar systems could aid in the identification process, and could have the ability to transmit large quantities of situational intelligence data.

Unmanned Vehicles

Although this study concentrated on manned aircraft, the use of fully automated unmanned vehicles (UVs) is worthy of comment. In some combat situations, such aircraft can be effective, and they reduce the loss of pilots. The technology is available to develop UVs that can perform automatically, without human intervention, such missions as defense suppression, reconnaissance, surveillance, and communications relay. Technology now under development for both manned and unmanned vehicles should allow the automatic performance of electronic warfare, damage assessment, and target assignment. The increasing power of small data processing machines has implications for the development of UVs, as do advances in sensors, structural materials, and propulsion technology. Given these developments, the prospects are increasingly good for including UVs as a part of a mixed force of combat aircraft. The principal obstacle to acceptance of unmanned aircraft is uncertainty about their costs.

Escape Systems

In some air-to-air and air-to-ground tactical maneuvers, departure from controlled flight does occur. When this happens, the aircraft may be at a speed and attitude that is at the edge of the safe ejection envelope. Even when ejection is possible, given the speed and attitude, the pilot has little time to recover the aircraft or to eject safely, if necessary.

Air Force and Navy statistics indicate that the survival rate of pilots who ejected from combat aircraft declined between 1976 and 1980. The survival rate in 1976 was 85 percent, in 1979 it was 70 percent, and in 1980 it was 72 percent.

In addition, during 1979 and 1980 there were as many ejections outside the escape envelope as there were in the previous three years. The fatality rate for Air Force pilots who ejected below an altitude of 500 feet was 57 percent during the past five years.

The Advanced Concept Ejection Seat II (ACES II) has improved the survival rate to some degree. The fatality rate is still unacceptably high, however, and solutions to this problem must be sought.

FINDINGS AND CONCLUSIONS*

1. The complexity of today's missions and high-performance aircraft has created workloads that at times impose intolerable demands on combat pilots.

2. Air Force development and application of automated features can improve operational effectiveness and enhance the chances for survival of pilots and combat aircraft.

3. The technology for automation of all routine tasks and of some others is now available. Full automation is costly and complex, however, and is not necessary in all manned combat aircraft.

4. The Air Force does not have an established position on the requirements for automation in aircraft.

5. There is currently no systematic, widely applied technology for allocating functions between automated systems and the pilot. Similarly, there is no criterion for balancing the costs of automating particular functions against the resulting improvements in combat performance.

6. Computer technology makes it possible to develop dynamic, integrated, and comprehensive automated systems for future combat aircraft. A systems approach, emphasizing the core function of flight trajectory and attitude control, is a logical and necessary starting point.

7. The aircrews' stated immediate need is for improved ability to fly low, at night, and during severe weather, using terrain for cover from enemy defenses. The critical and essential functions that could be automated to achieve this goal have not been completely identified, although current programs should illuminate this issue.

8. In such programs as AFTI-16 and LANTIRN, and in the development of technology for TF/TA, the Air Force research and development community is addressing important problems. These programs will develop technologies and an engineering perspective that are a valuable base on which to build. The approach remains piecemeal, however, and without clearly stated or widely understood objectives. A much-needed unifying focus is missing.

*No priority ranking is intended in the ordering of these findings and conclusions.

9. There is a large gap between what is known in a laboratory setting of the basic characteristics of human psychomotor performance, and what is known about how pilots actually fly and react in modern combat aircraft. Much of the knowledge needed to design an automated aircraft that uses pilots' skills to the best advantage lies within that gap.

10. In the past, the unreliability of avionics systems has been a major contributor to the downtime or unavailability of combat aircraft. No effort to improve combat performance by further automation can succeed without adequate attention to the reliability and maintenance of the equipment.

11. Fighter aircraft under development or now entering the inventory are not automated to the extent that the pilot is wholly free to assess and monitor the combat situation and to plan his further strategy. No aircraft has provided him with effective, accessible aids for assessing alternative strategies.

12. Insufficient attention has been paid to past efforts at automation. A study of such efforts could help developers to repeat past successes and avoid past shortcomings.

13. Identification of unknown objects as friend, foe, or neutral (IFFN) is difficult today. IFFN will become much more important in the future because of improvements in weapons' ranges.

14. In tactical maneuvers in high-performance aircraft, pilots often fly at the edge of the safe ejection envelope. Current automatic ejection equipment is inadequate for such situations; the number of injuries and fatalities suffered by pilots who eject from combat aircraft is increasing.

RECOMMENDATIONS

1. There is a recognized need for automation. The primary goals should be to increase combat effectiveness to enhance survival of pilots and aircraft, and to decrease pilot work load.

2. There is evidence that such automation can be available in the 1990s. A firm decision can and should be made to automate specific critical functions and/or infrequently performed but essential functions that are currently performed manually.

3. A systems-oriented program aimed at improving and developing automation for the 1990s should be initiated now. The goal should be a core design that would form the basis of automated functions, building on flight trajectory and attitude control systems. Such a systems approach could prevent piecemeal automation that could be costly and would result in only partial solutions not adaptable to growth.

4. Four functional groups are promising candidates for automation: (1) flight trajectory and attitude control, (2) engine and power systems control, (3) weapons delivery and fire control, and (4) navigation and communications functions. Combinations of these functional families can be accomodated by the evolving technology.

5. The increasing number of displays used to present information to pilots, the amounts of information and instructions displayed, the limited cockpit area available for display, and the otherwise complex environment of the aircraft have created special problems. Complicated displays are difficult to read, and controls and functional mode selection are cumbersome and time-consuming. Consequently, necessary actions may sometimes be neglected. To reduce pilot workload and increase operational effectiveness, functions that divert attention from critical actions should be automated.

6. A method for allocating functions between automated systems and the pilot must be developed. A multidisciplinary team should examine potential hardware and software techology, as well as human performance, to lay the basis for clear decisions in this regard. The objective should be a practical method for quantifying the improvements in performance and survival that result from automating particular functions.

7. A separate and fundamental study should be initiated to shed light on (1) the mental model pilots create to aid in performing their combat tasks, (2) the performance characteristics of the controls and displays through which the pilot and automated

systems interact, and (3) human capabilities. This study should develop a multitask, experimental and analytic program to model pilot behavior. This program could be used as an aid in designing advanced automated systems, and in particular the cockpits of the future.

8. Automating or partially automating a higher class of appropriate cognitive functions, such as the ability to assess the combat situation, or to plan strategies and escape routes, should be a part of the Air Force's long-range program.

9. The rising trend in fatalities and serious injuries relating to aircraft escape systems indicates a need for improvements. Air Force activity in modifying escape systems (ACES II) may meet this need. The problem must be addressed, through either the ACES II program or a completely new approach.

10. Identification of objects for beyond visual range as friend, foe, or neutral (IFFN) cannot be automated with any confidence today. An automated system for such identification would permit important gains in combat effectiveness. A coordinated effort on this front is needed.

ATTACHMENT E.3

CORRESPONDENCE

DR. JOSEPH BIRT

4711B Shaunee Creek Dr.
Dayton, OH 45415
October 30, 1985

Mr. Cyrus Crites
Chairman, Executive Board
DOD Human Factors Engineering
Technical Advisory Group
6520 Test Group/ENAH stop 239
Edwards AFB, CA 93523

Dear Cy and Members of the Executive Board,

I deeply appreciate the acknowledgement plaque dated May 8th which the Executive Board presented to me. Last minute work demands prevented my attendance at the surprise presentation meeting. Thank you for the professional recognition and acknowledgement by many friends and associates who signed the plaque.

The TAG has some unique things going for it. These characteristics are the secrets of its success:

- grass roots motivation
- an orientation to ongoing and planned activities
- an open, management-free environment

You need to protect them and keep up the good work.

Of all the mememtos I received upon retiring from the military, the DOD HFE TAG plaque was most meaningful to me. Thank you for your kind thoughtfulness. As you may know, I am now with the Battelle Columbus Division though still in Dayton. Although my perspective is changing, my government experience was indeed rewarding. I look forward to future affiliations with the TAG and with my military and civil service friends.

With high regards and sincere thanks, I remain

Respectfully yours,

Joseph A. Birt

cc: Louida D. Murray

ATTACHMENT F.1

CONTROLS AND DISPLAY -- MINUTES

MINUTES OF THE CONTROLS AND DISPLAYS SUBTAG

Submitted by
J. D. GROSSMAN

The SUBTAG for Controls and Displays met from 1830-2000, on 5 November 1985 in San Diego, CA, in conjunction with the main TAG. Approximately 35 people were in attendance.

Three presentations were made. Dr. Heather Wild described a study she has designed, and will conduct in the next few months at NADC, on CRT display size requirements for the A-6F aircraft.

The study will compare the proposed A-6F 5x5-inch display versus two larger sizes using simulated radar imagery on the display. Dr. Wild will evaluate the affect of size on aircraft safety and mission effectiveness. It is anticipated that Dr. Wild will present the results of this study at a future meeting.

Mr. Steven Kinsley briefed a recent NADC study on F-18 HUD pitch ladder formats. He compared performance with the current pitch ladder, against a proposed replacement and an ADI ball. The results, given the test conditions, were that where significant differences in performance occurred, performance with the ADI ball was best, followed closely by the current format. A discussion followed concerning the ramifications of the test design on the results.

Finally, a videotape was presented by Cy Crites, showing a liquid crystal flat panel display of aircraft engine instruments developed by GEC Avionics.

Following the presentation, there was a discussion about new tasks to be undertaken by the SUBTAG in recognition of the ostensible purpose of the group, which is to provide technical advice on controls and displays to the DOD/NASA. One task that was proposed would be to identify shortfalls in human factors guidelines, data and technology related to controls and displays. The SUBTAG expressed a clear concern that we are currently not in a position to provide guidance on the design of advanced controls and displays in aircraft, spacecraft, automated land vehicles or surface and subsurface ships now on the drawing boards. For example, there is a highly unsatisfactory technology base relating to controls and displays for multiple sensors, intelligent systems, and systems used in a weightless environment.

The outcome of the discussion was the formation of a working group that will attempt to identify these control/displays issues of the future.

One meeting of the working group has been held and another is scheduled. The objective of the group will be to develop a position paper on both near and long term issues, problems, shortfalls and needed technologies for advanced controls and displays. The position paper will be brought to the SUBTAG for a thorough review and approval and forwarded to the main TAG. We forsee that this effort will 1) provide the basis for directing future DOD/NASA efforts, 2) alert DOD and NASA management about TAG concerns for future system performance that depends on controls and displays, 3) and provide a basis for future SUBTAG discussions and presentations.

The next meeting of the SUBTAG will take place in conjunction with the main TAG meeting in May '86. It is proposed that the meeting be held on Monday of the week of the TAG meeting. Details of this proposal remain to be worked out.

ATTACHMENT F.2

A COMPARISON OF F/A-18 HUD AND ADI BALL DISPLAYS ON RECOVERY FROM UNUSUAL ATTITUDES

A COMPARISON OF F/A-18 HUD AND ADI BALL DISPLAYS ON RECOVERY FROM UNUSUAL ATTITUDES

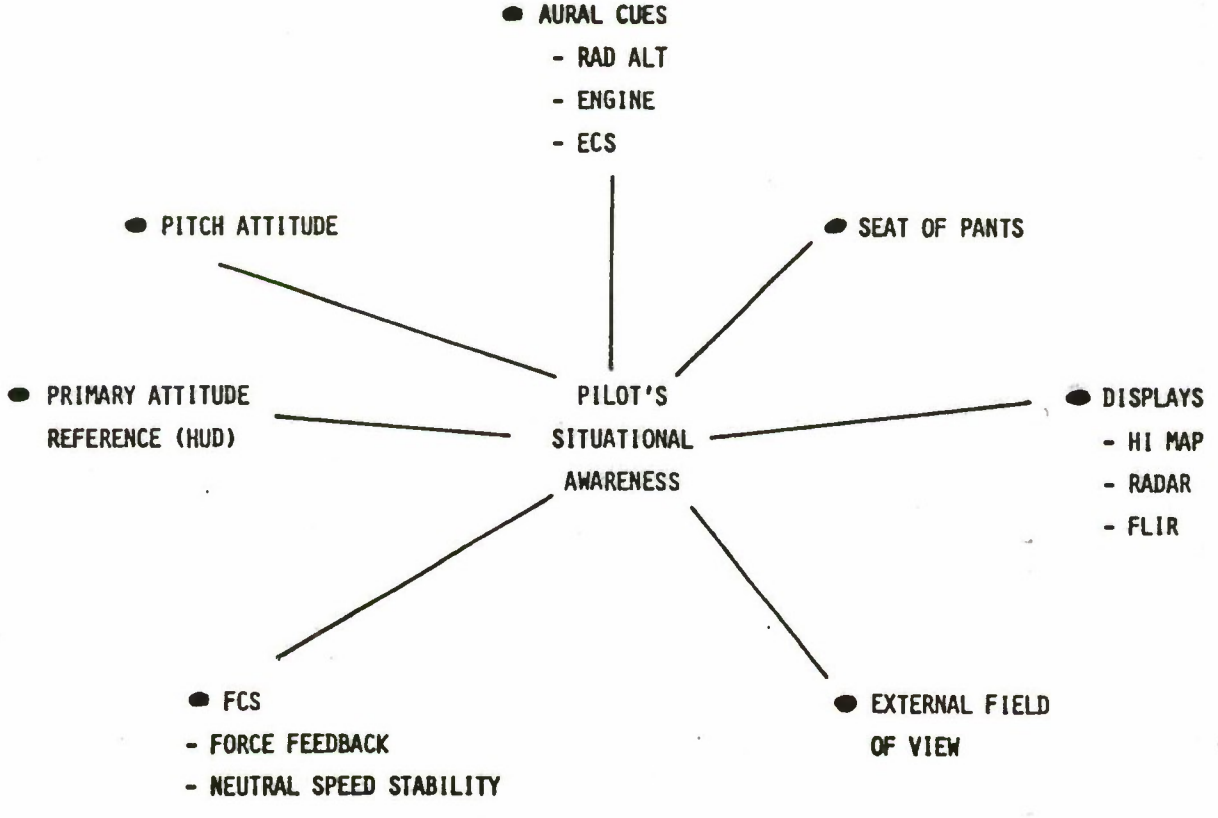
MR. STEVEN A. KINSLEY
MAN-MACHINE INTEGRATION DIVISION
TECHNOLOGY DEVELOPMENT BRANCH
NAVAL AIR DEVELOPMENT CENTER

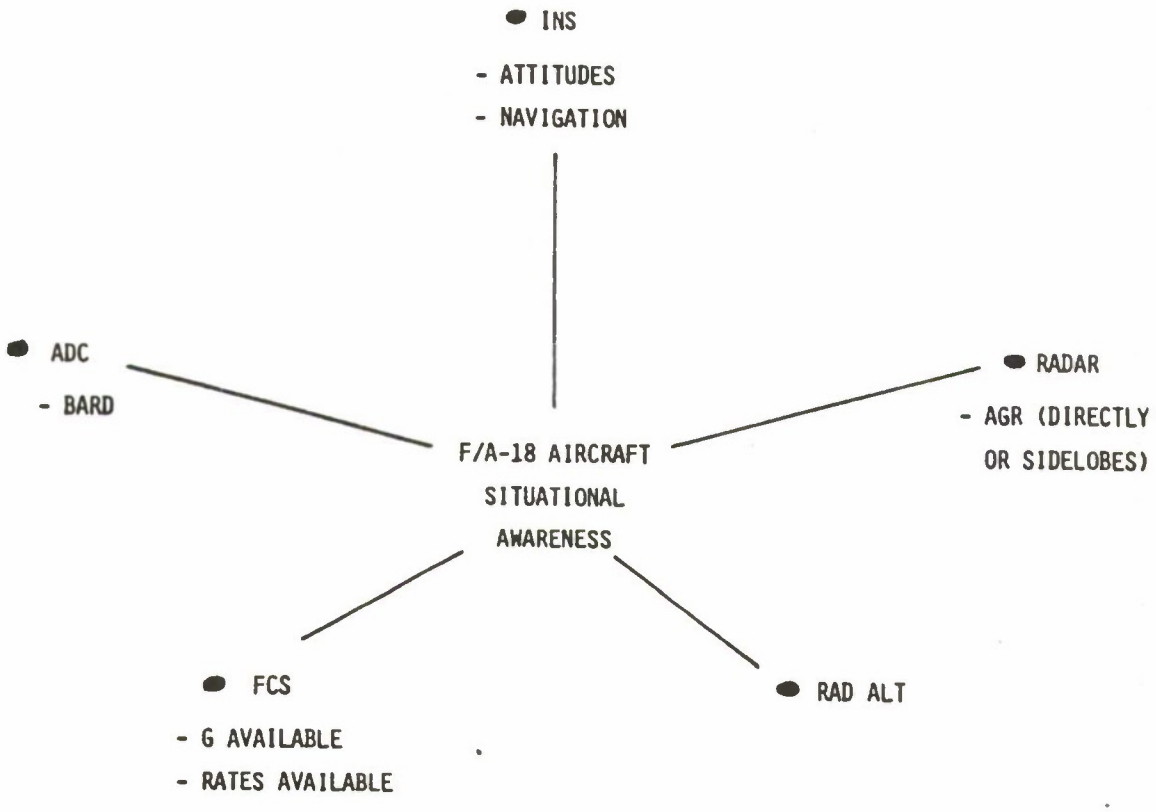
PROBLEM

- F/A-18 MISHAPS:
  - FLYING INTO WATER ON GCA DOWNWIND AT NIGHT
  - GROUND IMPACT DURING ACM
  - FLYING INTO GROUND DURING NIGHT FCLP WORK UPS

LOSS OF SITUATIONAL AWARENESS

- DURING TACTICAL MANEUVERING
  - ACM
  - AWI
  - BOMBING (TARGET FIXATION)
- DURING NON-TACTICAL MANEUVERING (I.E., CURRENT GPWS)
  - TAKEOFF/CATAPULT
  - INSTRUMENT APPROACH
  - SSSC



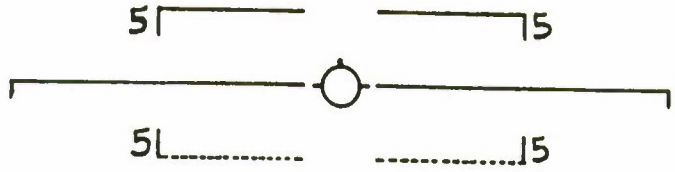


F/A-18 PILOT'S SITUATIONAL AWARENESS

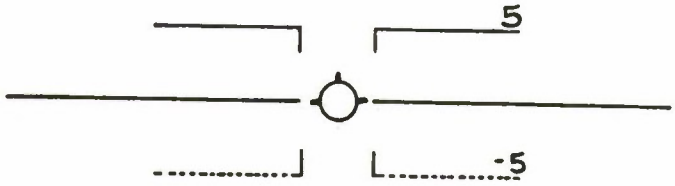
- FCS - MINIMAL FEEDBACK IN AUTO
- PITCH ATTITUDE - DOESN'T CHANGE WITH AIRSPEED CHANGES (FLAPS PROGRAM)
- HUD - NOT ADEQUATE FOR QUICK ATTITUDE RECOGNITION
- AURAL CUES
  - RAD ALT - OK
  - ENGINES/ECS - MINIMAL
- DISPLAYS
  - RADAR - EXP DISPLAYS DON'T CONTRIBUTE TO SITUATIONAL AWARENESS
  - FLIR - CAN BE VERY DISORIENTING
  - HI (MAP) - GOOD FOR NAVIGATIONAL SITUATIONAL AWARENESS

HUD CONCEPTS

F/A-18 HUD



PROPOSED HUD

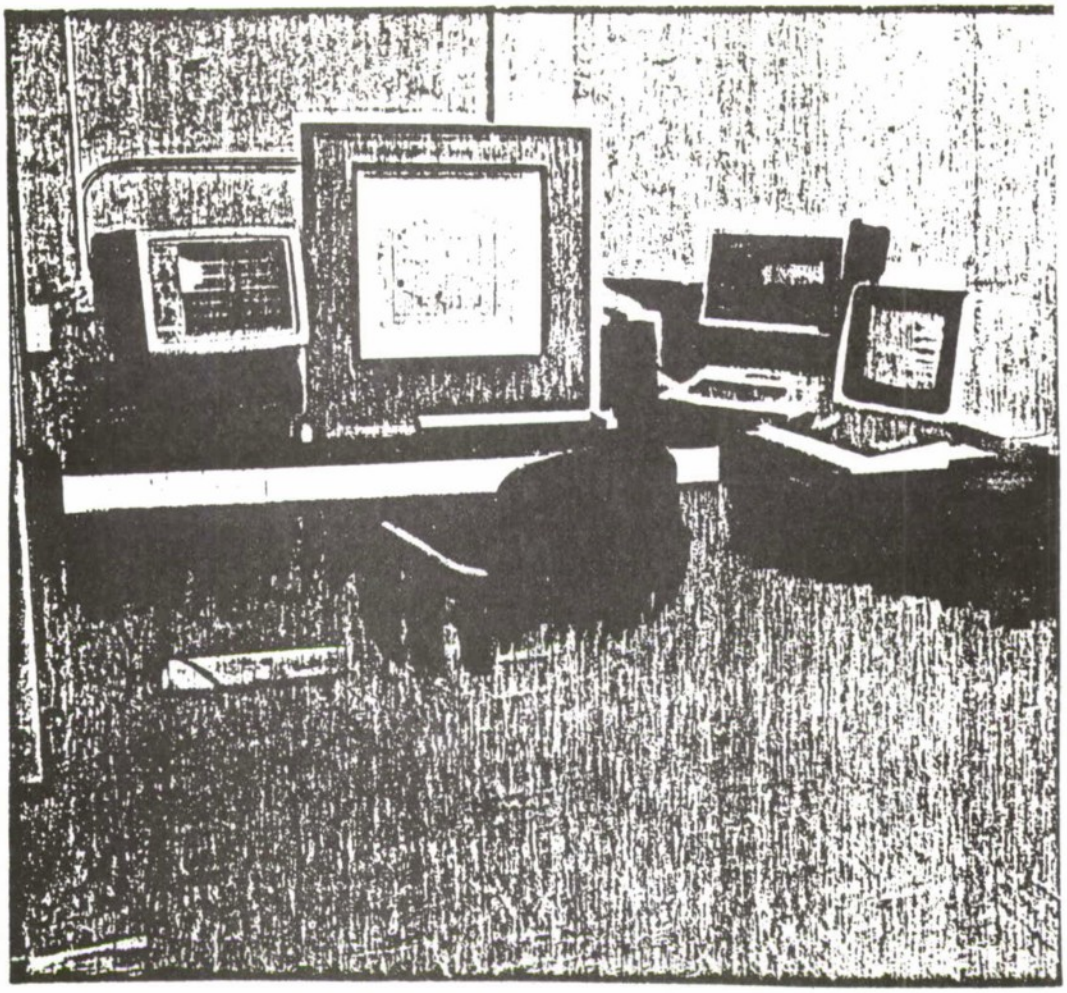


ADI BALL



EXPERIMENTAL PARADIGM
(STATIC EXPERIMENT)

	FORMAT		
	F/A-18 HUD	ADI BALL	PROPOSED HUD
	PITCH	PITCH	PITCH
ROLL	0° 55° -55°	0° 55° -55°	0° 55° -55°
0°	S1,S2,S3...S12		
60°			
120°		S1,S2,S3...S12	
180°			
-120°			
-60°			S1,S2,S3...S12



MEAN DECISION TIME AND PERCENTAGE ERRORS
AS A FUNCTION OF DISPLAY TYPE

DEPENDENT MEASURES	DISPLAY TYPE					
	F/A-18 HUD		ADI BALL		PROPOSED HUD	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
DECISION TIME	4.14	1.03	3.37*	0.94	4.43	0.99
% ERRORS	0.06	0.06	0.09	0.11	0.10	0.09

* SIGNIFICANTLY DIFFERENT (P .001) FROM OTHER TWO FORMATS

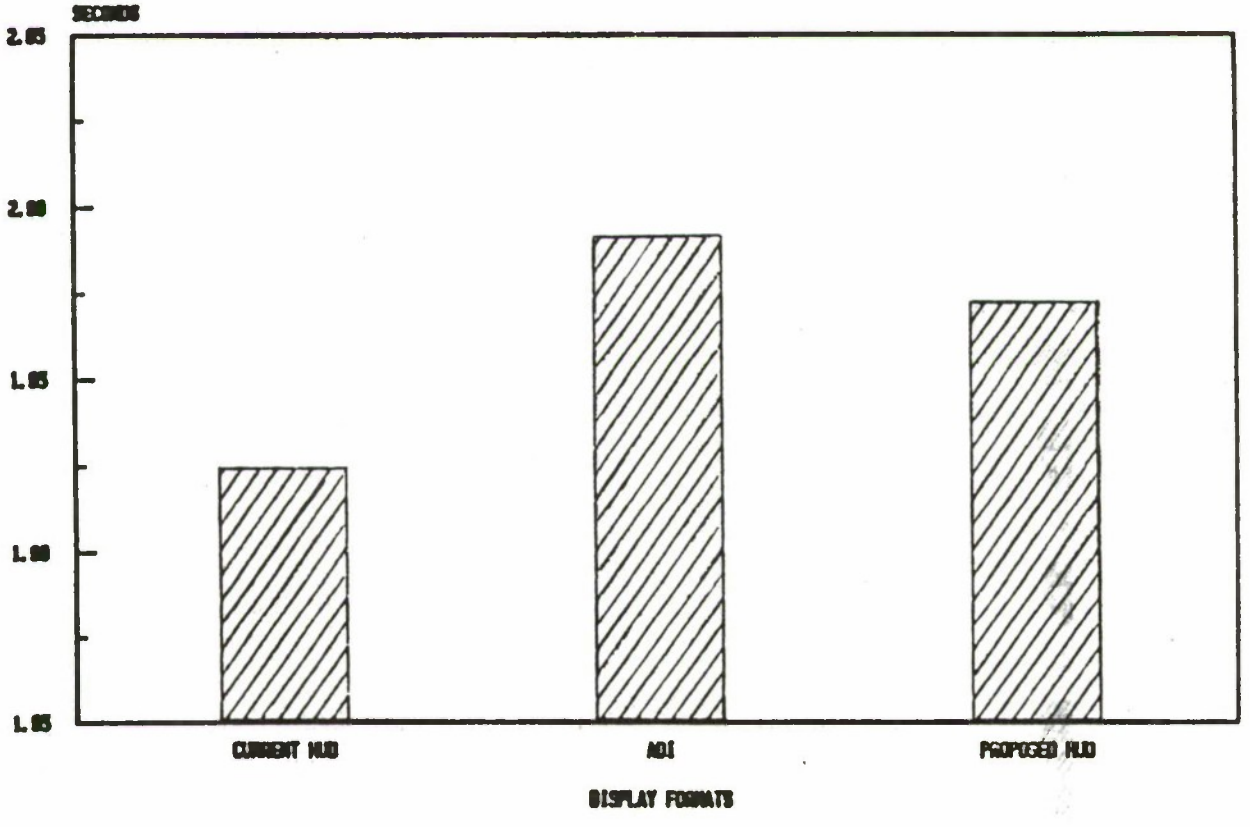
EXPERIMENTAL PARADIGM

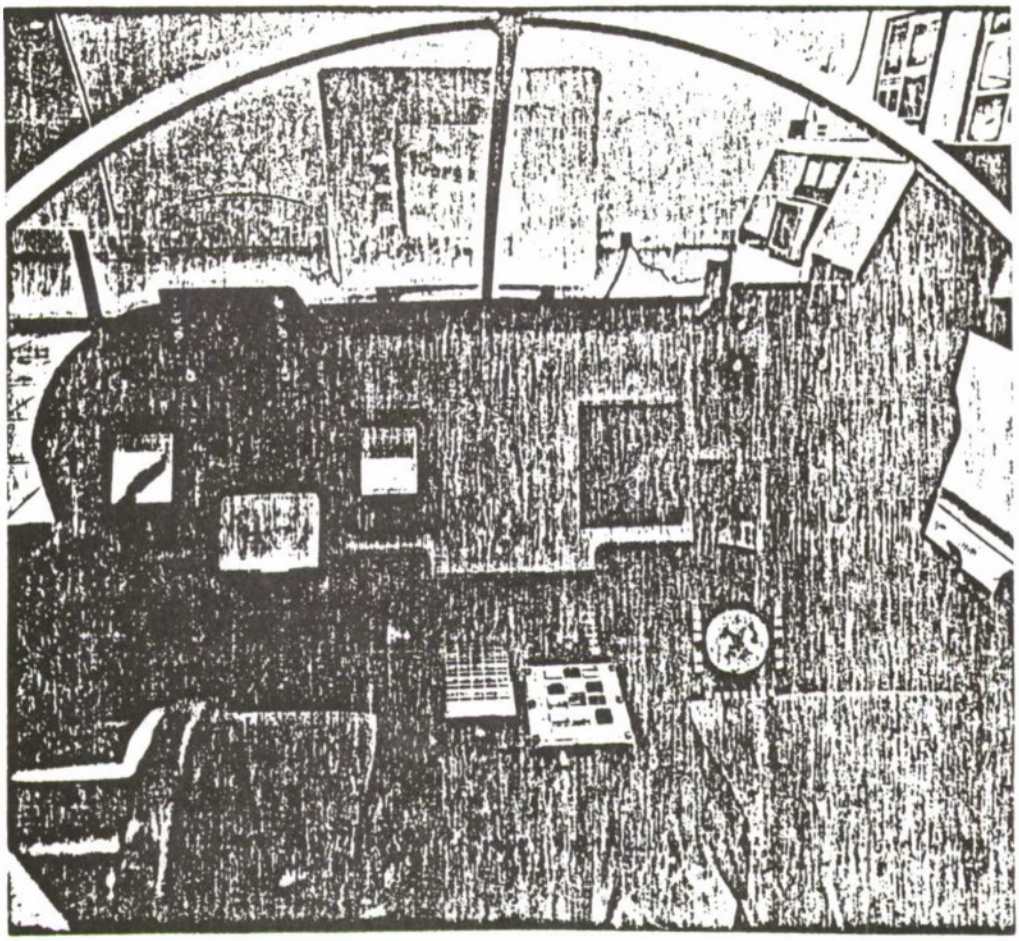
(DYNAMIC EXPERIMENT)

FORMATS

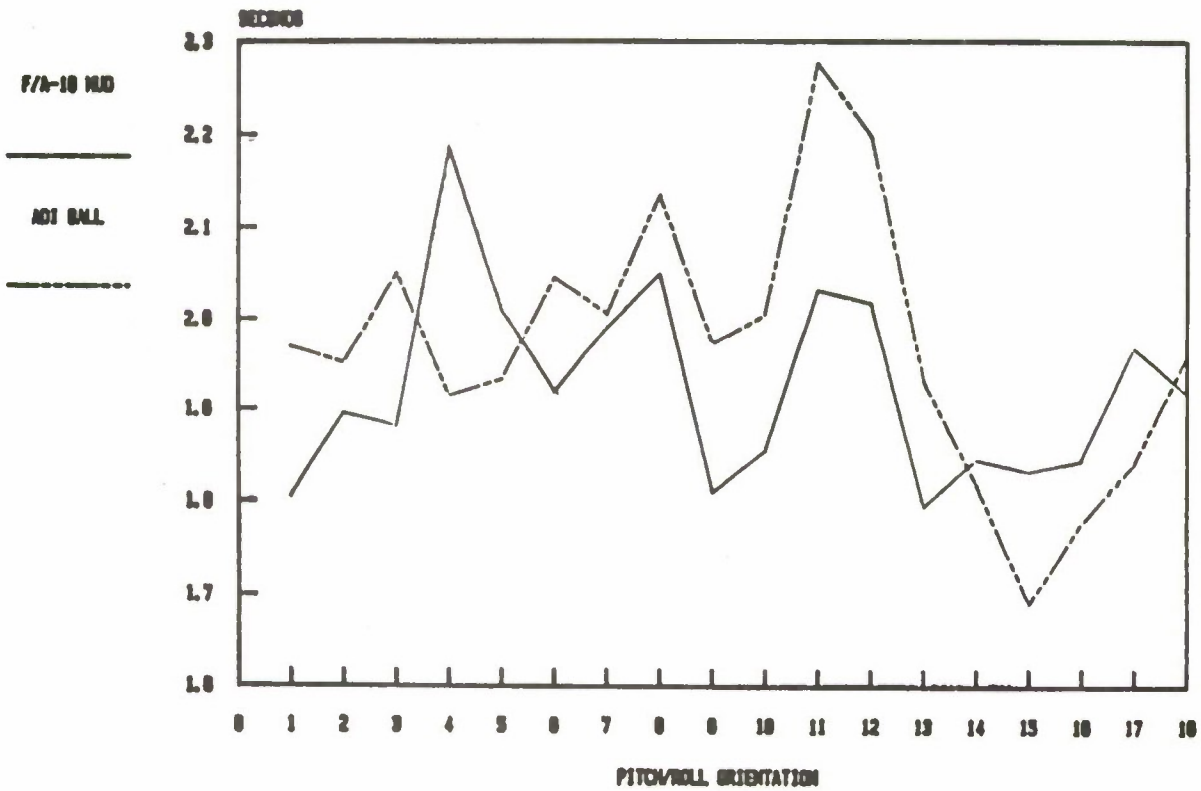
ROLL	F/A-18 HUD		ADI BALL		PROPOSED HUD	
	BACKGROUND		BACKGROUND		BACKGROUND	
	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
	PITCH 0° 55° -55°	PITCH 0° 55° -55°	PITCH 0° 55° -55°	PITCH 0° 55° -55°	PITCH 0° 55° -55°	PITCH 0° 55° -55°
0°	S 1-S12					
60°		S1-S12				
120°			S1-S12			
180°				S1-S12		
-120°					S1-S12	
-60°						S1-S12

MEAN DECISION TIME

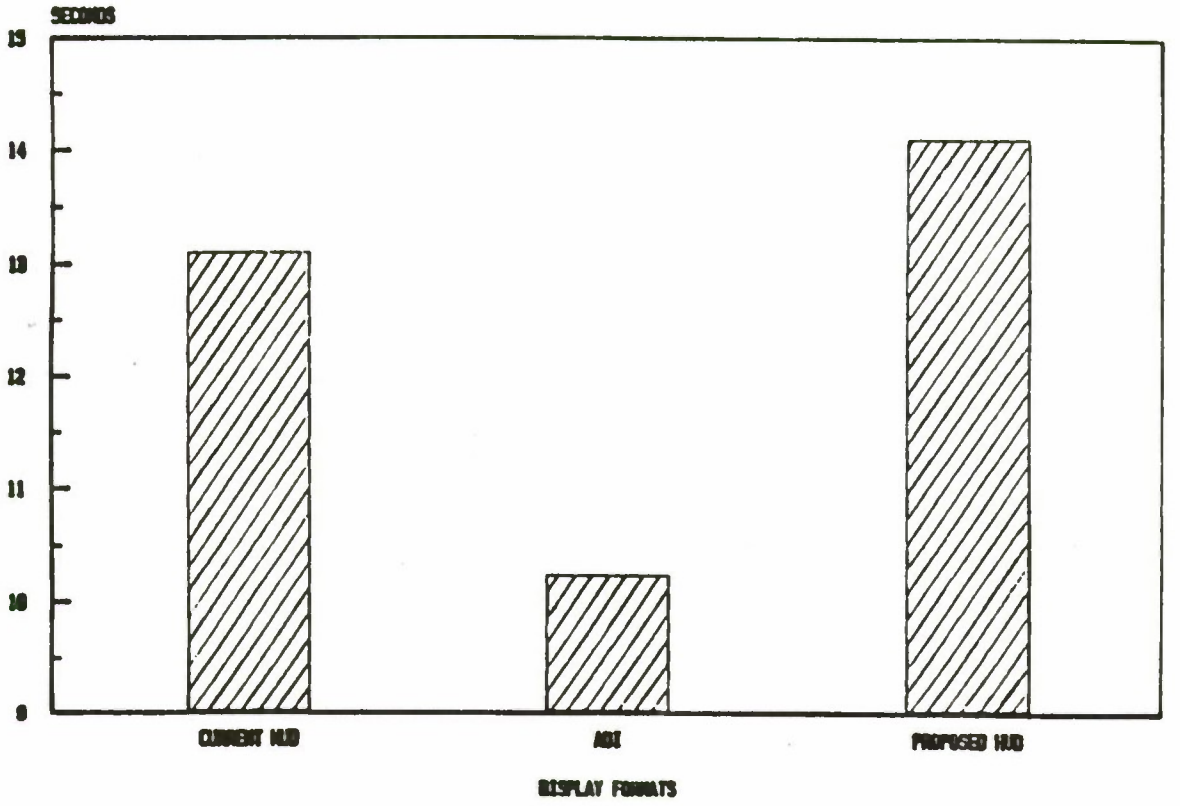




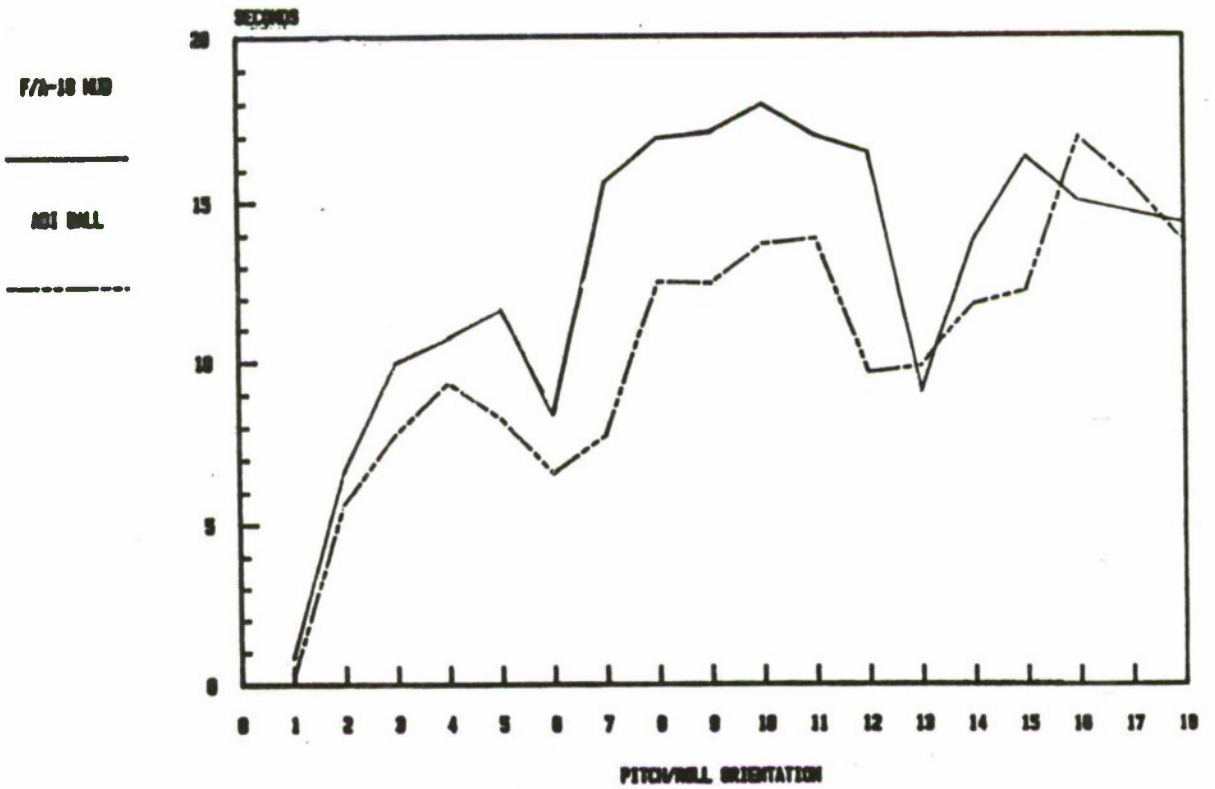
MEAN DECISION TIME



MEAN RECOVERY TIME



MEAN RECOVERY TIME



NUMBER OF ERRORS AS A
FUNCTION OF DISPLAY FORMAT
AND BACKGROUND CONDITION

	F/A-18 HUD	ADI BALL	PROPOSED HUD	
DAY	ERRORS = 23 MEAN = 2.091 S.D. = 2.071	ERRORS = 23 MEAN = 2.091 S.D. = 1.640	ERRORS = 19 MEAN = 1.727 S.D. = 1.272	TOTAL = 65
NIGHT	ERRORS = 32 MEAN = 2.919 S.D. = 2.427	ERRORS = 36 MEAN = 3.364 S.D. = 2.461	ERRORS = 33 MEAN = 3.000 S.D. = 3.109	TOTAL = 101
	TOTAL = 55	TOTAL = 59	TOTAL = 52	

ATTACHMENT F.3

EXPERIMENTAL EVALUATION OF DISPLAY SIZE

FOR THE A-6F AIRCRAFT



EXPERIMENTAL EVALUATION OF DISPLAY SIZE FOR THE A-6F AIRCRAFT

DR. HEATHER M. WILD
MAN-MACHINE INTEGRATION DIVISION
TECHNOLOGY DEVELOPMENT BRANCH
NAVAL AIR DEVELOPMENT CENTER

PROBLEM



- CURRENTLY 5" X 5" CRT DISPLAYS ARE PROPOSED FOR THE A-6F AIRCRAFT

- NO QUANTITATIVE ASSESSMENT OF THE REQUIRED A-6F DISPLAY SIZE

OBJECTIVE



- CONDUCT A QUANTITATIVE EXPERIMENT TO EXAMINE THE EFFECT OF THREE DISPLAY SIZES – 5" X 5", 6" X 6", 7" X 7" – ON A-6F OPERATOR TARGET DETECTION PERFORMANCE

BACKGROUND

- 5" X 5" DISPLAYS WERE INTRODUCED INTO THE A-6F AIRCRAFT IN THE ABSENCE OF EXPERIMENTAL EVALUATION. THE PRIMARY REASON FOR IMPLEMENTING THE 5" X 5" DISPLAY IN THE A-6F WAS TO ESTABLISH DISPLAY SIZE UNIFORMITY WITH THE F-14 AIRCRAFT

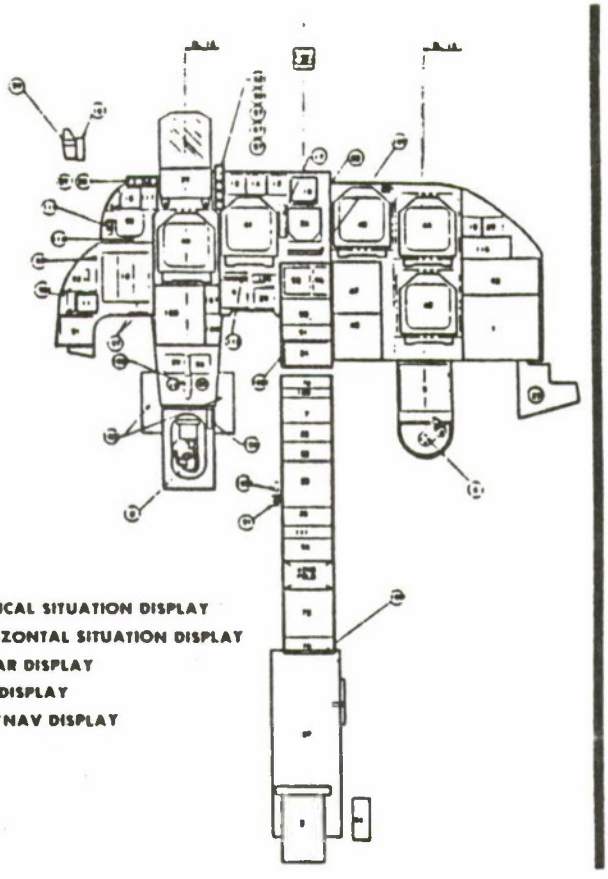
- SUBJECTIVE REPORTS FROM PILOTS AND B/Ns REVEAL THAT A LARGER THAN 5" X 5" DISPLAY IS PREFERRED

- RESEARCH HAS DEMONSTRATED A GREATER NUMBER OF CRASHES DURING SIMULATED HELICOPTER FLIGHTS USING 13-cm (5.12 in) DISPLAYS; HOWEVER, A DECREASE IN THE NUMBER OF CRASHES WAS NOTED AS DISPLAY SIZE INCREASED TO 26-cm (10.24 in)

- RESEARCH HAS DEMONSTRATED A GREATER PROBABILITY OF TARGET DETECTION AS DISPLAY SIZE INCREASED FROM 13-cm (5.12 in) TO 26-cm (10.24 in)

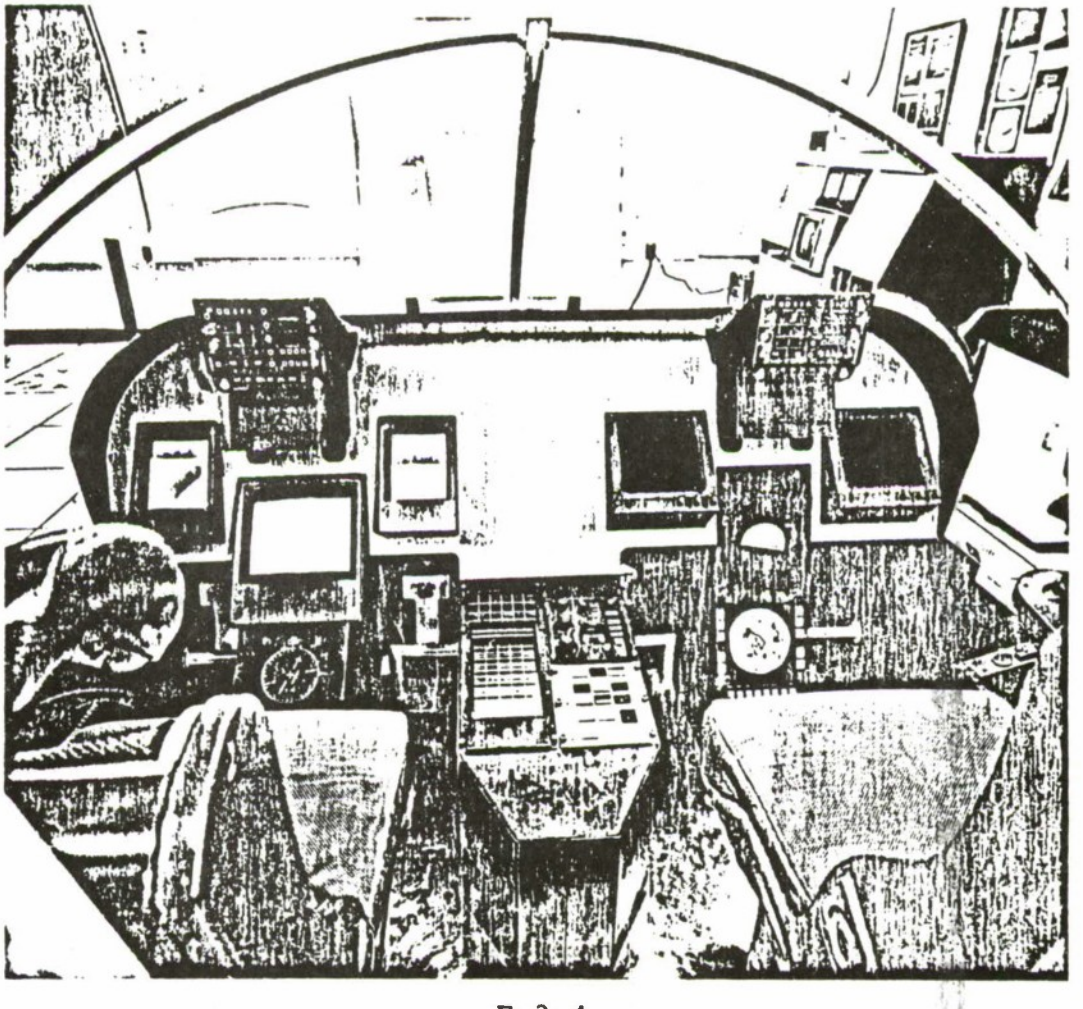
- RESEARCH HAS DEMONSTRATED THAT LOWER LUMINANCE LEVELS ARE REQUIRED WHEN USING 26-cm (10.24 in) DISPLAYS THAN WHEN USING 13-cm (5.12 in) DISPLAYS

- CONTRADICTORY RESULTS HAVE DEMONSTRATED THAT DISPLAY SIZE DOES NOT IMPACT ON PERFORMANCE

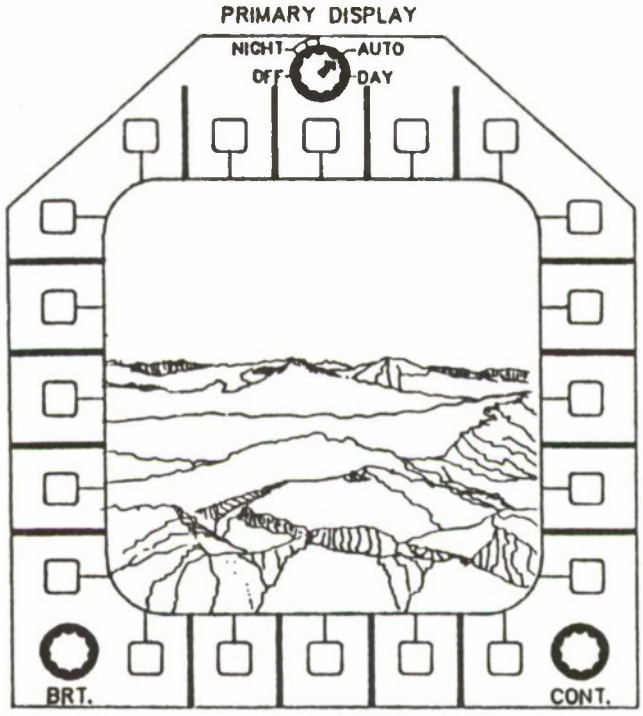


40 - VERTICAL SITUATION DISPLAY
41 - HORIZONTAL SITUATION DISPLAY
43 - RADAR DISPLAY
44 - FLIR DISPLAY
45 - SMS/NAV DISPLAY

A-6 UPGRADE DISPLAYS



PILOT MFD #1
TERRAIN FOLLOWING AND AVOIDANCE, ENEMY TERRITORY



EXPERIMENTAL PARADIGM

DISPLAY SIZE	5" X 5"		6" X 6"		7" X 7"	
ENVIRONMENTAL CONDITION	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
SUBJECTS	S_1 S_2 : : S_n	S_1 S_2 : : S_n	S_1 S_2 : : S_n	S_1 S_2 : : S_n	S_1 S_2 : : S_n	S_1 S_2 : : S_n

- DEPENDENT VARIABLES
  - NUMBER OF CRASHES LOGGED DURING EACH TRIAL
  - MEAN LUMINANCE LEVEL SET DURING FLIGHT
  - PERCENTAGE OF TARGET DETECTIONS
  - REACTION TIME TO TARGET DETECTION
  - MEAN ALTITUDE FLOWN DURING EACH TRIAL

- FIXER PARAMETERS
  - AIR SPEED
  - DISTANCE FROM DISPLAY TO EYE REFERENCE POINT
  - S/N RATIO
  - SYSTEM GAMMA FUNCTION

EXPERIMENTAL PROCEDURE



- TRAINING PHASE
  - INSTRUCTIONAL/FAMILARIZATION BRIEFING
  - SIMULATED FLIGHT PRACTICE
- TESTING PHASE
  - 5 MIN TRIALS
  - MULTI-TASKING → CONTINUOUS FLYING AND TARGET DETECTION
- QUESTIONNAIRE
  - WORKLOAD

HYPOTHESES PROPOSED



- THE NUMBER OF CRASHES OCCURRING DURING SIMULATED FLIGHT WILL DECREASE AS DISPLAY SIZE INCREASES
- REACTION TIME TO TARGET DETECTION WILL DECREASE AS DISPLAY SIZE INCREASES
- THE PERCENTAGE OF TARGET DETECTIONS WILL INCREASE AS DISPLAY SIZE INCREASES
- THE LUMINANCE LEVEL REQUIRED FOR VIEWING THE DISPLAY, PARTICULARLY DURING NIGHT CONDITIONS, WILL DECREASE AS DISPLAY SIZE INCREASES

SIGNIFICANCE OF EXPERIMENTAL RESULTS



- OBJECTIVE PERFORMANCE DATA FOR SELECTION OF DISPLAY SIZE IN THE A-6F
  - BENEFIT GRUMMAN AND NAVY (A-6 PMA)
- THE COMPATIBILITY OF THE 6" X 6" DISPLAY WITH THE 5" X 5" DISPLAY IN USE IN THE F-14 AIRCRAFT, IN TERMS OF PARTS AND COST, CAN BE DEMONSTRATED
- POSSIBLE
  - INCREASE TARGETS DETECTED
  - DECREASE TARGET DETECTION TIME
  - DECREASE DISPLAY LUMINANCE
  - DECREASE AIRCRAFT CRASHES

ATTACHMENT G

HUMAN FACTORS IN LOGISTICS -- MINUTES,

ATTENDEE LIST, RELATED MATERIALS

MINUTES FROM THE LOGISTICS SUBTAG GROUP
MEETING 5-7 NOVEMBER 1985, SAN DIEGO, CA
CHAIR MR. DALE MAHAR, PACIFIC MISSILE TEST CENTER

1. The Logistics SubTAG met late Tuesday night and was attended by a small group, five people to be exact, two from the USAF, one from the USA, one contractor from McDonnell Douglas Corporation and myself from the USN.

2. There were two presentations given; they both were very good and informative. The first was by Mr. Sheldon Levine of McDonnell Douglas Corporation on Design for Maintainability and the second by Ms. Wendy Campbell of Wright-Patterson AFB on the Lessons Learned Program.

3. Following the presentations, we entered into a discussion on whether the Logistics SubTAG should be cancelled due to the general lack of interest. After much discussion, it was decided that a name change appeared to be the correct direction in which to proceed. After several suggested names, it was agreed by all that were present, that the new proposed name would be Design for Supportability.

4. The Design for Supportability name was agreed upon due to the fact that it was more general in nature. It was generally agreed that Logistics, Design for Maintainability, Supportability, HFE, and training should be more integrated.

5. If there are any objections, changes or suggestions from any member of the Logistics SubTAG group that were not able to attend this meeting or from members of the mother TAG, please get in touch with me. Otherwise, I will initiate the agreed upon changes.

6. Enclosures (1) LOGSTAG Agenda, (2) Attendance List, and (3) Mr. S. Levine's viewgraphs from his presentation.

7. I wish to thank those that attended the Logistics SubTAG and especially Ms. Wendy Campbell and Mr. Sheldon Levine for their presentations.

Dale Mahar

DALE MAHAR
Logistics SubTAG Chair

LOGSTAG AGENDA
5 November 1985
1830-2000 Teak Room

Opening Remarks: Dale Mahar, LOGSTAG Chair

Presentations:

1. Mr. Sheldon Levine, McDonnell Douglas Corporation, St. Louis, MO
   Topic: Design for Maintainers

2. Ms. Wendy Campbell, Wright-Patterson AFB, OH
   Topic: Lessons Learned Program

Group Questions/Discussion

Old Business

New Business

Direction(s) LOGSTAG Should Proceed

Action Items

Closing Remarks

MANY OF TODAY'S MILITARY SYSTEMS CANNOT BE ADEQUATELY OPERATED, MAINTAINED, OR SUPPORTED BECAUSE THE DEPARTMENT OF DEFENSE DOES NOT PAY ENOUGH ATTENTION TO LOGISTIC SUPPORT, HUMAN FACTORS, AND QUALITY ASSURANCE DURING THE DESIGN PHASE OF THE ACQUISITION PROCESS.

DESIGNERS OF WEAPON SYSTEMS OFTEN DO NOT CONSIDER THE CAPABILITIES AND PERFORMANCE REQUIREMENTS OF THE PEOPLE WHO WILL OPERATE AND MAINTAIN THE SYSTEMS IN THE OPERATIONAL ENVIRONMENT. IT IS, THEREFORE, EXTREMELY IMPORTANT THAT WEAPON SYSTEM REVIEWS INCLUDE AN EVALUATION OF THE EXTENT TO WHICH DOD CONSIDERS MANPOWER, PERSONNEL, AND TRAINING NEEDS AND CAPABILITIES IN THE WEAPON SYSTEM ACQUISITION PROCESS.

HUMAN-INDUCED MALFUNCTIONS MAY BE A VERY SERIOUS PROBLEM

THE HUMAN LIMITATIONS OF THE OPERATOR AND MAINTAINER CAN CAUSE SYSTEM FAILURES. THE EXTENT OF THIS PROBLEM, HOWEVER, CANNOT BE ACCURATELY ESTIMATED FROM DATA IN CURRENT FAILURE REPORTING SYSTEMS. BASED ON INTERVIEWS WE CONDUCTED AND STUDIES WE REVIEWED, WE ARE CONVINCED THAT A LARGE NUMBER OF SYSTEM FAILURES ARE THE RESULT OF HUMAN ERROR. WE FOUND A DOD AND CONTRACTOR STUDY WHICH SHARE THIS POSITION. BOTH ESTIMATE THAT HUMAN ERRORS ACCOUNT FOR AT LEAST 50 PERCENT OF THE FAILURES OF MAJOR SYSTEMS.

THE INCREASINGLY COMPLICATED NATURE OF MODERN MILITARY SYSTEM TOGETHER WITH INTERNAL MILITARY PERSONNEL PROBLEMS SUGGESTS THAT HUMAN-INDUCED ERRORS BOTH IN OPERATIONS AND MAINTENANCE COULD ALSO INCREASE UNLESS MORE ATTENTION IS PAID TO THIS PROBLEM DURING DESIGN AND DEVELOPMENT.

GAO CONCLUSION - "IF THE DESIGN OF SYSTEMS IS TO ADEQUATELY CONSIDER ALL THE HUMAN LIMITATIONS (INCLUDING SKILL LEVELS, PROFICIENCY, AVAILABILITY, ENVIRONMENTAL STRESS, AND FATIGUE), MILITARY SPECIFICATIONS, STANDARDS, AND HANDBOOKS MUST ADDRESS THESE FACTORS. EXISTING DOCUMENTS DO NOT."

DEPARTMENT OF DEFENSE
HUMAN FACTORS ENGINEERING
TECHNICAL ADVISORY GROUP
5-7 NOVEMBER 1985
LOGSTAG ATTENDANCE LIST

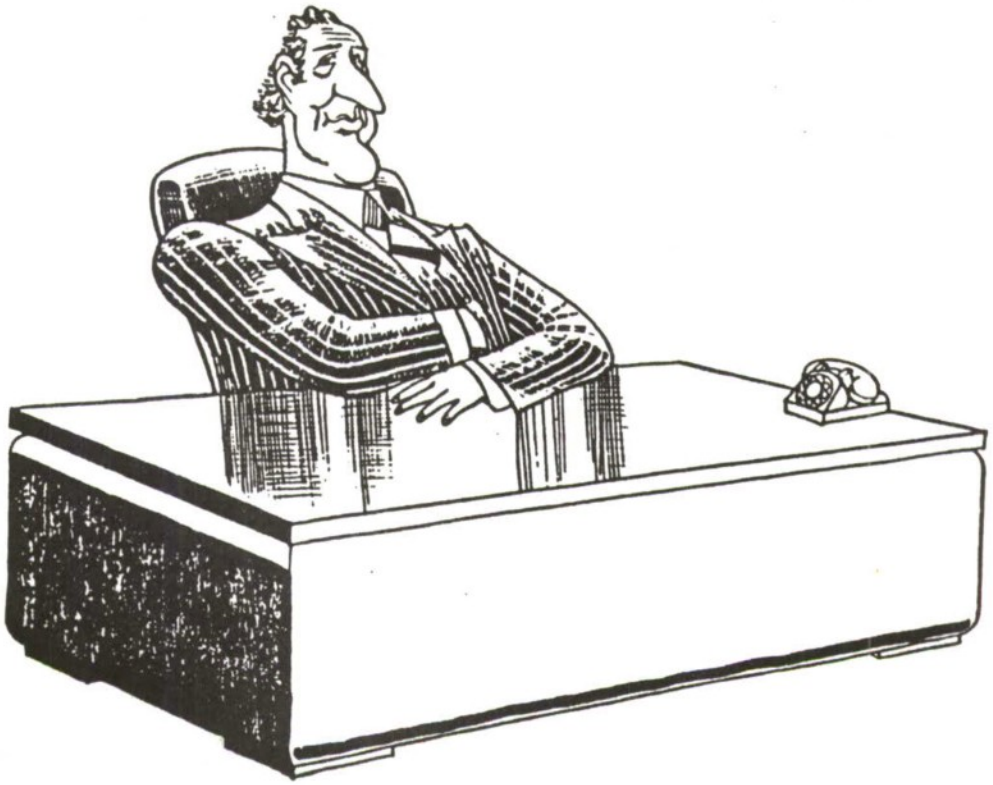
NAME	ADDRESS	PHONE (COMM/AV)	SPECIALTY AREA/SUGGESTED LOGSTAG DIRECTION
Dale Mahar SubTag Chairperson	Pacific Missile Test Center Code 4025 Point Mugu, CA 93042	(705) 989-8981 AV 351-8981	Design for Maintainability/Open to Membership Suggestions
Wendy Campbell	AFALC/EREM WPAFB OH 45433	(513) 255-4770 AV 785-4770	Which human factors/logistics interface can we "make the most money" and have the biggest impact? Training? Maintainability? Manpower?
Judah Katznelson	Army Research Institute 5001 Eisenhower Avenue Attn: PERI-SM Alexandria, VA 22333	(202) 274-8877 AV 284-8877	Manprint/Logistics and Manprint/ILS Interface
William B. Askren	Air Force Human Resources Laboratory AFHRL/LR Wright-Patterson AFB, OH 45433	(513) 255-3713 AV 785-3713	Design for Maintainability and Supportability; CAD/CAM; HF in Combat Maintenance Operations
Sheldon Lavine	McDonnell Aircraft Corp. St. Louis, MO	(314) 233-1718	Design for Maintainability and Supportability

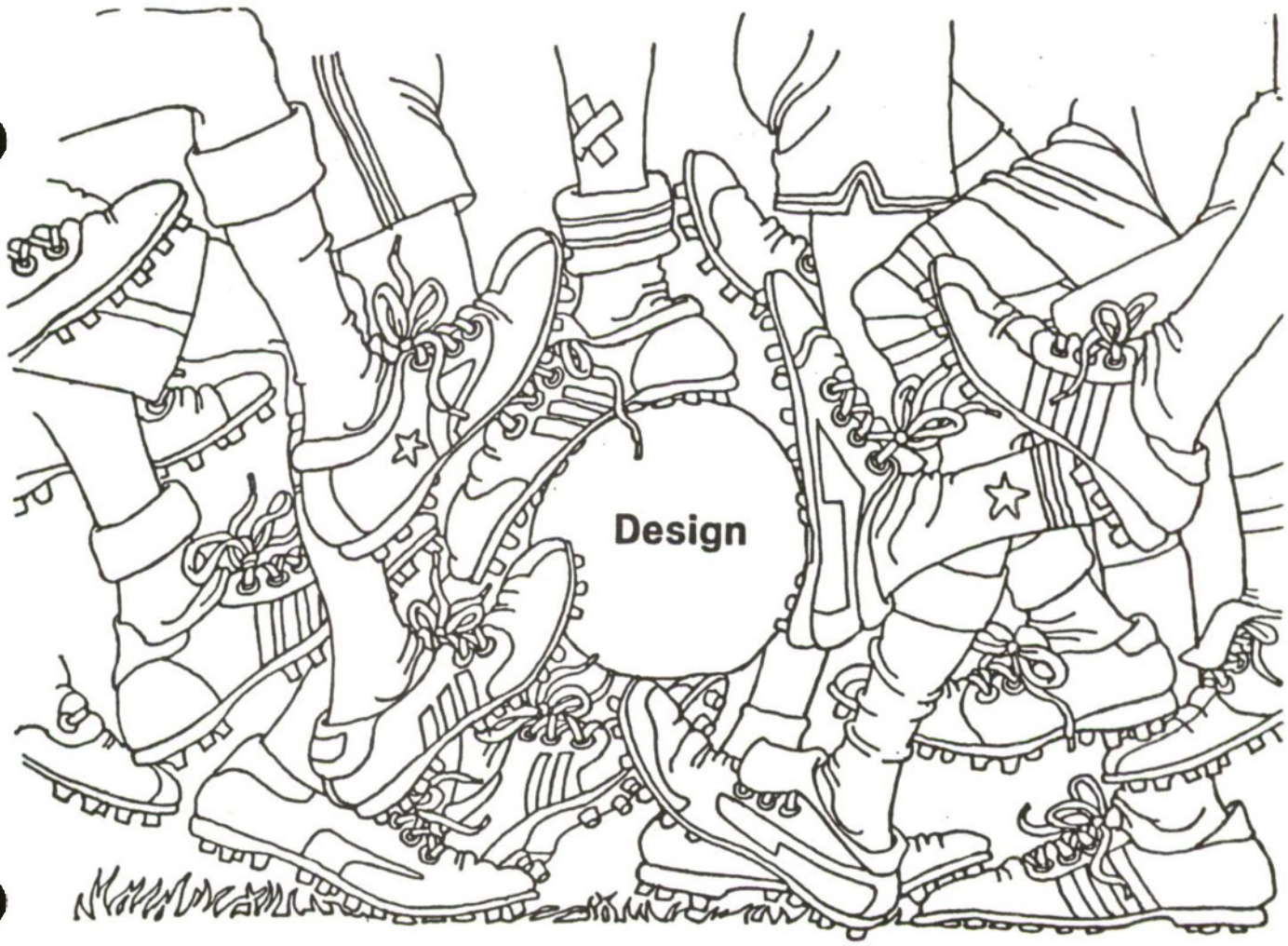
Design for Maintainer



SHELDON H. LEVINE

MCDONNELL DOUGLAS




Design

DATA ITEM DESCRIPTION
DI-H-7057

HUMAN ENGINEERING DESIGN APPROACH DOCUMENT-MAINTAINER (HEDAD-M)

ANALYSIS WORKSHEETS

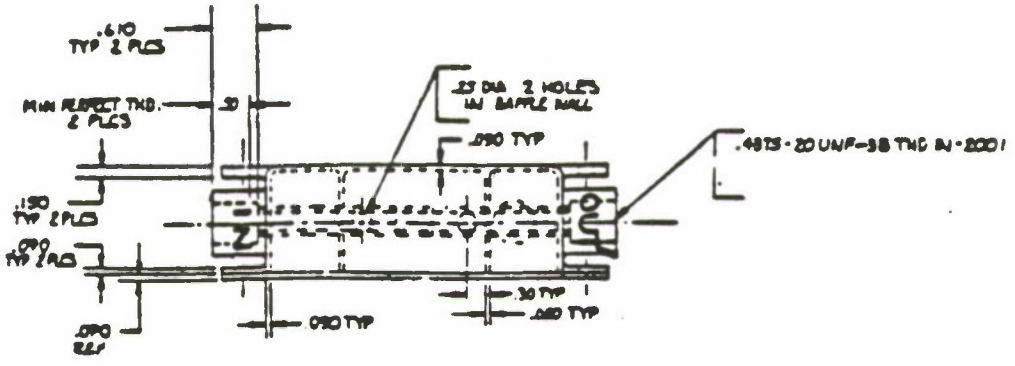
EQUIPMENT DESCRIPTION
DESIGN FOR MAINTAINER
FOOLPROOFING
TASK PROCEDURES

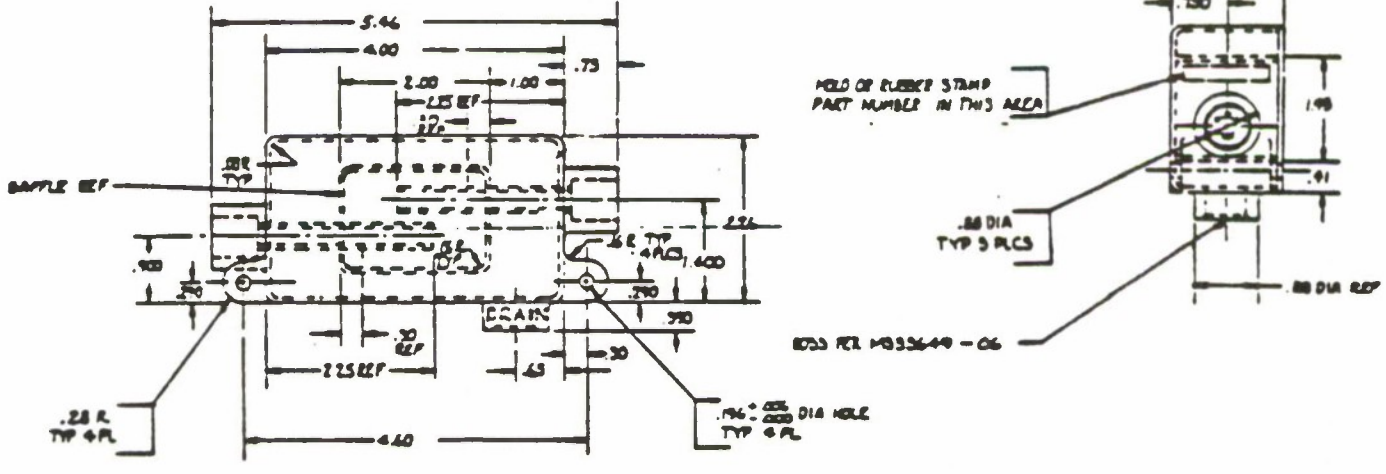
EQUIPMENT DESCRIPTION

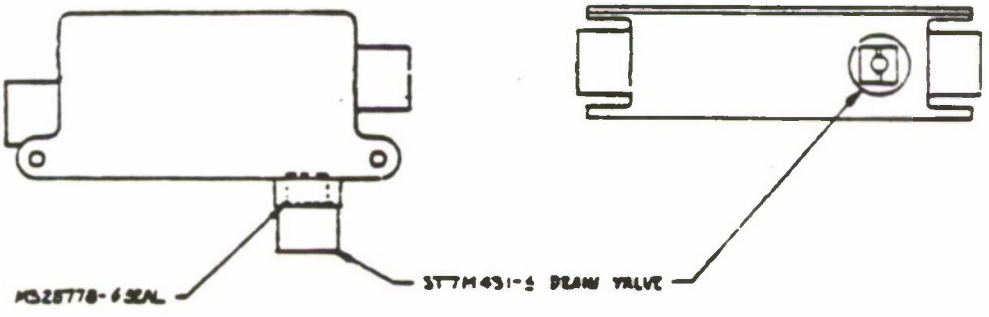
EQUIPMENT DATA
FUNCTION
MAINTENANCE TASKS
PHYSICAL CHARACTERISTICS
MOUNTING PROVISIONS
CONNECTIONS
ENVELOPE

EQUIPMENT ENVELOPE

WF:A: LEFT PITOT AND STATIC 2 MOISTURE TRAPS







GP41-0003-208

WRA: LEFT PITOT AND STATIC 2 MOISTURE TRAPS

VISUAL ACCESS: Visuel eccess is through door 122L, 59 inches off the deck. Drains ere located 3 inches below the door sill and 12 inches interior to the door openiog. Drain parts ere accessed from the moldline 54 ioches above the deck. Visual access will be obscured by the hands when reaching through the door opening. Drain is repleced from moldlioe aod has direct visual eccess from outside the aircraft.
PHYSICAL ACCESS: Physicel eccess is through door 122L, an 8 by 14 inch opening 59 ioches above the deck. A fifth percentile maintainer will need a workataod to reach the water traps which are 12 inches ioterior and 3 inches below the door sill. Moisture trap drain velves are accessed directly from the outside moldline end ere io reach of the fifth through ninety-fifth percentile mainteiner populetion.
LIFTING/CARRYING: Small and light enough to be carried by one man.
SAFETY: No additional safety features required.
MAINTENANCE CONTROLS/DISPLAYS: Ports on traps ere labeled IN end OUT.

FOOLPROOFING

REMOVAL

INSTALLATION

VERIFICATION

FOOLPROOFING

WRA: LEFT PITOT AND STATIC 2 MOISTURE TRAPS

FAILURE INDICATION: Cracked or damaged traps are detected by visual inspection. Pressure check of pitot static system will also isolate faulty traps. Drain valve failure will be indicated by an accumulation of water in the traps and no flow when traps are emptied during daily inspection.

REMOVAL: Drains are removed in direct line from mounting bracket. Traps are of convenient size for one hand removal. Tubes are removed before mounting bolts. Flats are provided on adapter to hold trap steady while loosening connector. To disconnect tube from moisture trap, loosen connector nut and pull tubing free. Removing connector nut can result in loose parts internal to the fitting being lost.

REPLACEMENT: Connectors are sized so as not to cross connect pitot and static systems. Drain valve opening in mounting bracket ensures proper orientation of trap. Bolts and nuts are installed in either orientation. Procedure for tightening connector fittings is outlined in Technical Manuals Adapter and connectors both must be held steady while tightening.

INSTALLATION VERIFICATION: Visually inspect traps. Pitot static pressure test to ensure integrity of the system.

GP41-0003-209

REMOVAL/INSTALLATION PROCEDURE

WRA: LEFT PITOT AND STATIC 2 MOISSTURE TRAPS

PERSONNEL NUMBER:	1	**NEC/MOS:**	AE83XX/6335	**SKILL LEVEL:**	B

SUPPORT EQUIPMENT/MATERIALS: MIL-G-4343 aircraft grease, MS28775-113 packing for pitot static trap, torqua wranch (5 to 50 lbs), wranches, MIL-S-8660 silicone compound , MS28775-6 packing for drain valve.

1. REMOVAL:

1.1 Open door 122L (28 Hi Torque fastenars).
1.2 Looseo connector (2) fittings (about 1/2 turn) and pull tube free of fitting.
1.3 Remove outs and remove bolts from mounting adapter.
1.4 Remove trap.
1.5 Remove connector fittiogs from trap.
1.6 Remove old packing from connector fittings.

Note: To remove drain valve unscrew using 3/8 io socket wrench.

2. INSTALLATION:

2.1 Lubricate new packing and iostall on adapters.
2.2 Install coooector fittiogs into trap and tighten 1/4 turn past fioger tight.
2.3 Install trap into mounting adapter on aircraft (2 bolts washers and outs).
2.4 Install tubes into connector fittiogs and tighten per Techoical Manual.
2.5 Perform pitot static pressure test.
2.6 Secure door 122L (28 Hi Torque fasteners).

Note: To replace drain valve, grease packing, install packing oo drain valve, apply coating of silicone compound to threads, iostall into trap and torque to 20-30 inch-pounds.

100% COMPLETED AND DELIVERED PRIOR TO FIRST FLIGHT

FAILURE IDENTIFICATION

Failed WRA identified	Pilot Report Bit Inspection Warning/Caution/Advisory Scheduled Change
Isolate failed WRA for R/R	Maintenance Bit Troubleshooter per T.O. WRA failure indicator Door/Shelf/Part labels to locate part

REMOVAL

Mounting Design	FOD potential, dropped fasteners and lockwire etc. Blind access - hidden fasteners/ connectors Direct line removal-damage to WRA and adjacent objects Handling of WRA during removal Order of removal of connectors and fasteners Lighting and carrying placards
Connectors	Clearance of hard lines during removal Loose hardware and parts Consistency of operation for removal Force requirements for removal Interlock on removal from rack or tray Placard on safety Pressure relief (hydraulics)

REPLACEMENT

Mounting Design	Installation orientation and alignment Interchangeability FOD Installation sequence Torque Placards and Labeling

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Design Approach Document-Maintainer	DOD	DI-H-7057

3. DESCRIPTION/PURPOSE
This document provides a source of data to evaluate the extent to which equipment having an interface with maintainers meets human performance requirements and human engineering design criteria.

4. APPROVAL DATE
1 June 1979

5. OFFICE OF PRIMARY RESPONSIBILITY
ARMY/MIRADCOM

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP
This DID replaces DI-H-2108 and UDI-H-21385.

This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.2 of MIL-H-46855B.

9. REFERENCES (MANDATORY AS CITED IN BLOCK 10)
MIL-H-46855B
MIL-STD-1472

NCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering Design Approach Document - Maintainer (HEDAD-M) shall be prepared which describes the characteristics, layout, and installation of all equipment having a maintainer interface (excluding depot level maintenance actions); it shall also describe maintainer tasks associated with the equipment. The HEDAD-M shall describe the extent to which the requirements of MIL-STD-1472 and other applicable human engineering documents specified in the contract have been incorporated into the design, layout, and installation of equipment having a maintainer interface. Maintainer task analysis results shall be presented as part of the rationale supporting the layout, design and installation of the equipment. The requirement for this information is predicated on the assumption that, as analytic and study information, it is developed sufficiently early to influence the formulation of other system data such as maintenance allocation charts, special repair parts/tool lists, LSAR data. If the program has progressed to the point where the required data is available through other reporting media, such as those noted above, they shall not be duplicated but shall be referenced or appended to the HEDAD-M along with appropriate supplementary information fulfilling the intent of this provision.

10.2 Content Requirements. The HEDAD-M shall consist of the following information:

1) List of each item of equipment having a maintainer interface at the Organizational and Field/Intermediate Maintenance Activity (IMA) level, a brief statement

10. PREPARATION INSTRUCTIONS (continued)

task number, task title, task frequency (for scheduled maintenance actions) or estimated task frequency (based on equipment mean-time-between-failure for unscheduled maintenance actions), data source used (e.g., drawing number, sketch number, development hardware, actual production equipment), detailed task sequence (see paragraph 6.2.5 of MIL-H-46855B), support equipment required, tools required, job aids required, estimated task time, estimated personnel requirements (e.g., number of personnel required, skills and knowledge required) and human engineering considerations which reflect specific human engineering requirements incorporated into the design (e.g., maintainer fatigue, potential hazards, safety or protective clothing/equipment required or recommended, access problems, maintainer communication requirements, special task sequence requirements, labeling). As applicable, the following types of maintainer tasks shall be addressed by task analyses: remove/replace, trouble-shoot (fault location), repair, adjust, inspect, service and test. Critical tasks (see paragraph 6.2.1 of MIL-H-46855B) shall be clearly identified.

7) Narrative which provides rationale for any need to deviate from, or take exception to, MIL-STD-1472 or other contractual item human engineering requirements.

8) Two sketches, drawings or photograph of each of equipment having a maintainer interface. Each item of equipment shall be depicted, a) by itself from top, front and side (three-view trimetric or exploded trimetric view) and b) installed as the maintainer would normally view it during maintenance.

9) Sketches, drawings or photograph of each item of equipment being considered as alternatives to the selected, or baseline design. Sketches, drawings or photographs of alternative equipment installations or layouts which exist at the time of HEDAD-M preparation.

10) Description of design, installation or layout changes which have been made since the last HEDAD-M submission.

10.3 Format and Data Organization Requirements. The HEDAD-M be prepared in contractor format except that information shall be presented in two major parts:

1) Information pertaining to maintenance actions performed at the Organizational Level.

2) Information pertaining to maintenance actions performed at the Field/IMA level.

*U.S. GOVERNMENT PRINTING OFFICE: 1979-603-023/5044

ATTACHMENT H

HUMAN FACTORS TEST AND EVALUATION --MINUTES

ATTENDEE LIST, RELATED MATERIALS

Minutes of the Test and Evaluation
Sub-Technical Advisory Group Meeting
of 5 November 1985

The Test and Evaluation Sub-Technical Advisory Group (T&E STAG) met on 5 November 1985. This meeting was held in conjunction with the 15th meeting of the Department of Defense Human Factors Engineering Technical Advisory Group (HEF TAG) in San Diego, California. The meeting of the T&E STAG was limited to three hours, but much was accomplished.

Approximately 50 people attended the meeting, 42 of which signed the attendance sheet (enclosure (1)). Keith Karn (Naval Air Test Center) chaired the meeting and wrote these minutes, filling in for CDR William Moroney, the T&E STAG Chairman, who was unable to attend.

Keith opened the meeting, welcomed attendees, presented the agenda shown in enclosure (2), announced the open and the government only sessions, and gave a brief update on test and evaluation equipment and procedures under development at the Naval Air Test Center.

Two invited presentations were made by people from Essex Corporation. Dr. Betina Babbit gave a presentation on the construction of questionnaires. The presentation was based on her recently published questionnaire construction manual. The presentation and the manual cover topics including types and content of questionnaires, attitude scales, anchoring, administration of questionnaires, characteristics of respondents, and evaluating results. Her presentation is enclosure (3). The manual has been printed by Essex Corporation. It was written in conjuction with Charles Nystrom of the Army Research Institute. The report will be available through DTIC soon.

Roger McTighe also of Essex Corporation presented the Essex Training Analysis System (enclosure (4)). This is a micro-computer based data collection, manipulation, and reporting system designed to aid the human factors engineer in developing job analyses, task analyses, job performance measures, and training objectives. Although the system was developed for the Nuclear Power Industry, its flexibility was demonstrated by using it to develop a task analysis for a tune up of a 1979 Hona Civic. Demonstration Disketts are available from Essex. The system runs on IBM PC and compatible systems.

After these two Essex presentations, the remaining portion of the meeting was for government personnel only, at the request of the T&E STAG chairman.

Dr. Dave Meister (Naval Personnel Research and Development Center) presented the results from a recent survey of human factors professionals in test and evaluation. His survey covered the frequency of use, utility, and ease of use of various test and evaluation methods, practices, and procedures. He found a high correlation between frequency and ease of use and also a high correlation between frequency of use and utility. He also presented interesting responses on constraints that practicing human factors engineers face in the test and evaluation environment. His presentation is enclosure (5).

Ms. Jan Stoliker (Edwards Flight Test Center) discussed her work on the AFTI F-16. She is currently involved in obtaining man-in-the-loop system performance data from the 1553 data bus. She is collecting information about target tracking accuracy (comparing automatic vs. manual modes), airspeed, altitude, and flight control position. Jan is also collecting workload data using biomedical measures and subjective ratings. Although the results will not be available until a future meeting, these methods appear to be useful and demonstrate great potential for tapping into the 1553 bus for a wealth of data (see enclosure (6)).

Dr. Jim Geddie (Army Human Engineering Lab) gave a brief update on the task analysis handbook and proposed military standard. Drafts of these documents are in review by an AD HOC committee. The T&E STAG membership may see a somewhat smoother version by the next meeting. After review by the T&E STAG, the proposed military standard will be sent to the standardization committee.

Mr. Tom Enderwick (Naval Personnel Research and Development Center) made a short presentation on interaction between the T&E STAG and the Test and Evaluation Technical Group of the Human Factors Society. Tom is active in both groups. He presented the purpose and activities of the Human Factors Society T&E Group and invited participation (enclosure (7)).

The meeting ended with a discussion of new business. Dr. Jim Geddie was selected as the new chairman of the T&E STAG. The group also passed a motion to adopt the concept of chair-select as many of the other SUB-TAGs have. This allows for an individual to be identified for the chairmanship a year in advance. During the year prior to his/her chairmanship, this person will act as an assistant to the incumbent chairperson. Selection of an Air Force representative for the chair select position should occur prior to the next T&E STAG meeting.

The T&E STAG was invited to the Human Engineering Laboratory, in Aberdeen, Maryland for the next meeting. This meeting will be held independently of the main TAG meeting in April 1986.

Overall, this was a productive meeting. The attendance list shows participation from many research and development centers as well as the test and evaluation groups. This type of participation emphasizes the importance of test and evaluation during all phases of product development.

NOTE: The rationale for declaring several of the presentations "Government Only" was questioned during the meeting of the operating board. It was decided that for future discussions the criteria for the "Government Only" designation should be the same as the criteria used for classifying reports. These minutes include copies of viewgraphs from all presentations made at this meeting (including the "Government Only" session.) This was done with the permission of the presenters as they determined that no contractor-sensitive data was included.

Human Factors Test and Evaluation SubTAG

Attendee List

5 November 1985

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TEST AND EVALUATION SUB-TAG
5 November 1985 (1:30 - 4:25)
Lani Room, Kona Kai, San Diego

----------OPEN SESSION----------

1:30	Introductory Remarks	Keith Karn (NAVAIRTESTCEN)
1:40	Questionnaire Construction	Betina Babbit (Essex)
2:10	Task Analysis System	Roger McTighe (Essex)

----------GOVERNMENT ONLY----------

2:55	T&E Practices; Survey Results	Dave Meister (NPRDC)
3:20	AFTI Data from 1153 Bus Manual vs. Automatic Tracking	Jan Stoliker (Edwards AFB)
3:40	Task Analysis Handbook and Proposed Mil. Standard	Jim Geddie (TCATA/HEL)
3:55	Interaction Between Human Factors Society T&E Tech Group and T&E STAG	Tom Enderwick (NPRDC)
4:10	New Business (New Chair, Next Meeting, Open Discussion)	

LITERATURE SURVEY AND BIBLIOGRAPHY
QUESTIONNAIRE CONSTRUCTION

5 NOVEMBER 1985

BRIEFING PRESENTED BY:

DR. BETTINA BABBITT
ESSEX CORPORATION
741 LAKEFIELD ROAD
WESTLAKE VILLAGE, CA 91361

COMPUTER ASSISTED LITERATURE SEARCH AND MANUAL SEARCH

DIALINDIX DATABASES	NUMBER OF CITINGS BY DATABASE	ACTUAL NUMBER OF ABSTRACTS IDENTIFIED
NTIS National Technical Information Services, U.S. Department of Commerce	6,766	32
SOCIAL SCISEARCH Institute for Scientific Information	1,448	25
COMPENDEX Engineering Information, Inc.	462	0
PSYCINFO American Psychological Association	466	38
ABI/INFORM Data Courier, Inc.	2,384	51
SOCIOLOGICAL ABSTRACTS	189	1
MANAGEMENT CONTENTS	3,359	2
U.S. POLITICAL SCIENCE DOCUMENTS University of Pittsburgh Center for International Studies	72	1
HEALTH PLANNING AND ADMINISTRATION U.S. National Library of Medicine	1,688	11
ERIC Educational Resources Information Center	50	5
Manual Search Journals and Books		177
TOTAL	16,816	343

COMPARISON OF SCALE CHARACTERISTICS

- Author
- Subjects
- Number of Subjects
- Number of Experimental Conditions
- Types of Conditions
- Number of Scale Dimensions
- Number of Scale Points
- Types of Anchors
- Hypotheses Measured
- Results
- Scale Reliability
- Scale Validity

Questionnaire Items

Open Versus Closed Questions

Balanced Questions

Length and Number of Items

Order of Items

Wording of Items and Tone of Wording

Survey Considerations

Cognitive Complexity

Interviewing

Training

Age

Consequences of Informed Consent

Ethnic Background

Education

Non-Response Rate

Respondent Anxiety

Respondent Preference for Format

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P-77-2
Questionnaire Construction Manual
Annex
Literature Survey and Bibliography
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A. Overview
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D. Situational Factors
E. Training Interviewers
F. Data Recording and Reduction
G. Special Interviewer Problems

QUESTIONNAIRE CONSTRUCTION MANUAL ANNEX: LITERATURE SURVEY AND BIBLIOGRAPHY

QUESTIONNAIRES: LITERATURE SURVEY AND BIBLIOGRAPHY

SURVEY RESEARCH HAS PROGRESSED IN DIVERGENT LINES FOR DIFFERENT FIELDS

- Public Opinion Surveys More Or Less Dropped Thurstone Scales In The 1930's
- Likert And Guttman Scales Are Primarily Used
- Market Research Uses The Semantic Differential Most Frequently
- Performance Appraisals Have Usually Been BARS, BOS, BES
- Behavioral Scales Developed For Selection And Morale
- Performance Tests, Pilot Qualification, Moving Toward Guttman Model, Adaptive Testing

FORCED RESPONSE AND MULTIPLE CHOICE SCALES
BEHAVIORALLY ANCHORED RATING SCALES (BARS)

Developed to measure morale for military units (Motowidlo and Borman, 1977)

Scale Point	Behavioral Anchor
9	When maintenance mechanics found an error in their assembly procedures on an aircraft, they told their platoon leaders of their mistake and requested that the hangar be open Saturday and Sunday if necessary to meet their previously promised Monday deliver.
8	While clearing the brush from an approach to an airport, these dozer operators never shut the dozer off, running in shifts right through lunch.
7	This section was asked to prepare a set of firing charts by a specific time. The charts were finished ahead of time.
6	Although this section was constantly called upon for typing tasks, the work was done with few mistakes and on a timely basis.
5	The men in this unit did not push for top performance, although they did their jobs and kept busy.
4	Many troops in this unit would leave the post as quickly as possible after duty hours to avoid doing any extra work.
3	The service section of a support unit had a large backlog of equipment needing repair. All enlisted personnel assigned to this section appeared to be busy, but their output was very low compared to the other service sections.
2	The men in this section signed out weapons to be cleaned but sat around and "shot the bull" until it was time to turn the weapons back in.
1	During one period these enlisted personnel slowed their work down and made mistakes that cost time and new parts. They were working 7-day weeks, but at the end of the period they were accomplishing only the same amount of work in 7 days that they had been accomplishing before in 5 days.

New Trends To Increase Reliability And Validity, And Reduce Rating Errors

- Expert Judgment Or Respondent Judgment For Developmental Procedures
- Specified Percentage Levels Of Agreement
- Training By Amount Of Time And By Content
- Training Respondents To Reduce Rating Errors
- Filter Questions Assess Consciousness Of Respondents

SCHUMAN, H., & PRESSER, S. QUESTIONS AND ANSWERS IN ATTITUDE SURVEYS: EXPERIMENTS ON QUESTION FORM, WORDING, AND CONTEXT. NEW YORK: ACADEMIC PRESS, 1981.

- Interviewers Should Only Record A Don'T Know Response When A Respondent Spontaneously States That.
- Don't Know Responses Should Not Be Included As A Fixed Category.
- Telephone Interviewing Or Face-To-Face Interviewing Had No Systematic Effects On Survey Research Although Telephone Respondents Avoid Questions That Would Lengthen The Interview.

WEEKS, M. F., & MOORE, R. P. ETHNICITY-OF-INTERVIEWER EFFECTS ON ETHNIC RESPONDENTS. PUBLIC OPINION QUARTERLY, 1981, 45, 245-249.

- A Difference In Ethnicity Between Interviewer And Reepondent Does Not Effect The Survey Responsee To Non-Sensitive Queetions.

FORCED RESPONSE AND MULTIPLE CHOICE RECOMMENDATIONS

- The langth of an item may possibly modify tha responsa styla. Researchers may wish to develop alternate versions of survey items of varying length.
- Prior to format selection, the type of measurement scale and data analysis should be identified.
- No one scaling format has consistently been superior to another. Rating scales need to be evaluated on other criteria than number of scale points, vertical and horizontal formats, and unipolar or bipolar scalas (Baltramini, 1982; Zedack, Kafry, & Jacobs, 1976).
- Multiple-choica items can be daveloped with maasure higher order objectives (Aikan, 1982).
- The development of survey items should includa pilot testing using open-ended items which ara later converted to forced rasponse and multiple choice items (Schuman and Pressar, 1981).
- Forced responsa and multiple choice items ara dosired when measuring soft data such as opinions, and chack-lists ara recommended for hard data such as physical aspects of a job analysis or a broad generalization for measruing opinions prior to a later survay (Moroney, 1983; Orlich, 1978).

- Minor violstions in the technique of scsle development for bipolar anchors, such ss quasi-polar anchors and phrases for anchors, do not appear to threaten the reliability of the instrument (Vidali, 1976; Dickson & Albaum, 1977). Therefors, it is possible to establish new versions for bipolar anchors.

- Researchers need to be careful about the selection of bipolar scales when messuring concepts since reliability of the scales will not insure validity. The sslection of bipolar anchors in developing a new scale would be more useful if the validity of the scale was measured.

- Further research is required in the development of pictorially anchored bipolar scales. Nonverbal pictorial anchors would eliminate the problem of translating non-verbal stimuli to verbal anchors. The spplication of pictorial anchors for semi-literste raters may be more functional for that group of rsters than having them try to interpret verbal anchors.

- The analysis of individual items in bipolar scales will not provide sufficient levels of reliability so that several dimensions are required to be summed.

- To avoid any potential socially desirable response sets, it would be possible to anchor the bipolar scale with two socially desirable anchors. However, this approach would violete the assumptions of bipolarity for the meaning, intensity, and direction of the seman-tic spacs. Since evidence regarding the effects of response style has been mixed, it would be better to retain the bipolarity of the scale.

A DECADE OF CHANGE

SURVEYS ARE CONDUCTED BY COMPUTER

- **Random Digit Dialing**
- **Computer To Respondent Via Telephone**
- **Respondent On Computer Terminal**

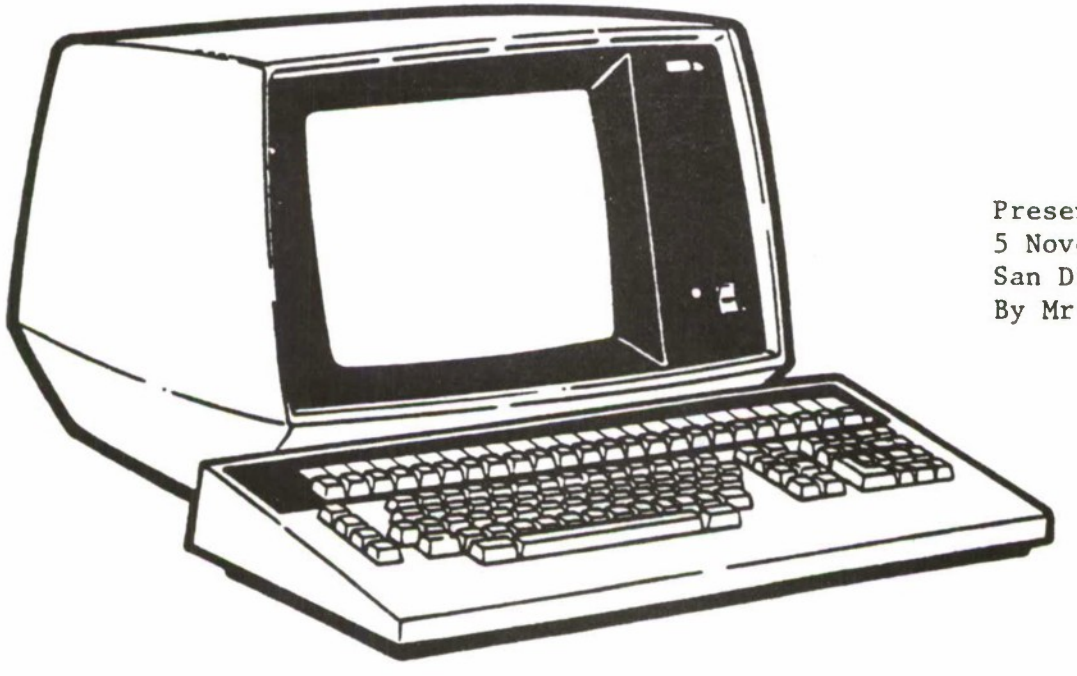
WHERE DO WE GO FROM HERE?

- SCALE DEVELOPMENT PROCEDURES AND ANALYSES
- PROCEDURAL GUIDES TO ITEM WORDING
- AUTOMATED PORTABLE TEST SYSTEMS
- COGNITIVE COMPLEXITY
- BEHAVIORALLY ANCHORED RATING SCALES

CUT YOUR TRAINING COSTS WITH ETAS©

The ESSEX Training Analysis System (ETAS) is a computer-based data collection and report generating system that has been developed to aid in the application of Training Systems Development (TSD).

SAMPLE REPORT OUTPUT



Presented at T&E SUB-TAG
5 November 1985
San Diego, California
By Mr. Roger McTighe

ESSEX

PAGE NO. 1
08/31/85

AUTO TUNE-UP MECHANIC

TASK I.D. NUMBER	TASK TITLE	PERFORM. FREQUENCY	IMPORTANCE	LEARNING DIFFICULTY	TIME SPENT	TOOLS AND EQUIPMENT	REFERENCES
100010101	REMOVE SPARK PLUGS	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100020101	SPARK PLUG INSPECTION, CLEANING AND GAPPING	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100030101	INSTALLATION OF SPARK PLUGS	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100040101	POINTS AND CONDENSER INSPECTION	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100050101	POINTS AND CONDENSER REMOVAL	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100060101	POINTS AND CONDENSER INSTALLATION	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100070101	ADJUSTMENT OF POINTS WITH A FEELER GAUGE	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100080101	ADJUSTMENT OF POINTS WITH A DWELL METER	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
100090101	CHECK IGNITION TIMING, ADJUST IF REQUIRED	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			

PAGE NO. 1
08/31/85

AUTO TUNE-UP MECHANIC

CUT OFF POINT = 2.12

TASK I.D. NUMBER	NUMBER RESPONSES	PERFORM. FREQUENCY 1	2	3	4	5	AVG	STD	IMPORTANCE 1	2	3	4	5	AVG	STD	LEARNING DIFFICULTY 1	2	3	4	5	AVG	STD	RELATIVE TRAINING PRIORITY NUMBER
REMOVE SPARK PLUGS																							
100010101	15	0	0	10	2	3	3.5	0.83	0	0	0	12	3	4.2	0.41	0	0	0	5	2	3.6	0.74	3.98

TOOLS USED: COMMON TOOLS FOR PERFORMING A TUNE-UP
REFERENCES USED: REPAIR MANUAL ISBN 0-8019-7473-9,PG 288,296-299

SPARK PLUG INSPECTION, CLEANING AND GAPPING																							
100020101	15	0	0	15	0	0	3.0	0.00	0	0	0	5	2	3.6	0.74	0	12	3	0	0	2.2	0.41	2.98

TOOLS USED: WIRE BRUSH
REFERENCES USED: REPAIR MANUAL

INSTALLATION OF SPARK PLUGS																							
100030101	15	0	0	12	3	0	3.2	0.41	0	0	10	0	5	3.7	0.98	0	0	5	5	5	4.0	0.85	3.83

TOOLS USED: SPARK PLUG WRENCH
REFERENCES USED: REPAIR MANUAL

TITLE: REMOVE SPARK PLUGS

SYSTEM/DUTY NUMBER: 100
TASK NUMBER : 001
ACTIVITY : 01
JOB : 01

PARENT TASK : ** NONE **
PARENT ELEMENT: ** NONE **

GENERAL CONDITIONS:
1 ENGINE MUST BE COOL TO THE TOUCH

INITIATING CUE(S):
1 WORK ORDER FOR TUNE-UP SIGNED BY CUSTOMER AND SUPERVISOR

ELEMENTS — ELEMENT RELATED CONDITIONS, STANDARDS, REFERENCES, TOOLS & EQUIPMENT, SKILL & KNOWLEDGES

1 MARK EACH SPARK PLUG WIRE WITH A PIECE OF MASKING TAPE AND NUMBER IT ACCORDING TO ITS CORRESPONDING CYLINDER.

FLAG : C
CONDITIONS :
REFERENCES : 1 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299
STANDARDS :
TOOLS/EQUIP : 1 MASKING TAPE
2 LINT FREE CLOTH
SKILLS/KNOWLEDGE:

104101011400 — LOCATION OF COMMON HANDTOOLS

104101051700 — OPERATION OF COMMON HANDTOOLS

111111111101 — LOCATION OF TUNE-UP INFORMATION FOR A 1979 CIVIC OR CVCC IN THE REPAIR MANUAL

111111111102 — LOCATION OF SPARK PLUGS

111111111110 — LOCATION AND SEQUENCE OF SPARK PLUG WIRES

111111111115 — LOCATION OF THE CYLINDER BLOCK

333333333301 — ABILITY TO INTERPRET AUTO TUNE-UP PROCEDURES (INSTRUCTIONS FOR THE JOB FUNCTION)

2 REMOVE SPARK PLUG WIRES FROM THE SPARK PLUGS BY GRASPING THEWIRE BY THE END OF THE RUBBER BOOT AND TWISTING OFF.

FLAG : C

CONDITIONS : 1 ENGINE IS COOL TO THE TOUCH
REFERENCES : 1 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299
STANDARDS :
TOOLS/EQUIP :
SKILLS/KNOWLEDGE:

111111111101 — LOCATION OF TUNE-UP INFORMATION FOR A 1979 CIVIC OR CVCC IN THE REPAIR MANUAL

111111111102 — LOCATION OF SPARK PLUGS

111111111110 — LOCATION AND SEQUENCE OF SPARK PLUG WIRES

333333333301 — ABILITY TO INTERPRET AUTO TUNE-UP PROCEDURES (INSTRUCTIONS FOR THE JOB FUNCTION)

3 LOOSEN EACH SPARK PLUG WITH SPARK PLUG SOCKET (13/16 IN.)

FLAG : C
CONDITIONS : 1 ENSURE AREA AROUND EACH PLUG IS KEPT CLEAN
REFERENCES : 1 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299
STANDARDS :
TOOLS/EQUIP : 1 13/16 IN. SPARK PLUG SOCKET
2 SPARK PLUG WRENCH
SKILLS/KNOWLEDGE:

111111111101 — LOCATION OF TUNE-UP INFORMATION FOR A 1979 CIVIC OR CVCC IN THE REPAIR MANUAL

111111111102 — LOCATION OF SPARK PLUGS

333333333301 — ABILITY TO INTERPRET AUTO TUNE-UP PROCEDURES (INSTRUCTIONS FOR THE JOB FUNCTION)

4 UNSCREW EACH PLUG AND REMOVE FROM THE ENGINE

FLAG : C
CONDITIONS : 1 ENSURE THE AREA AROUND EACH PLUG IS FREE OF FOREIGN OBJECTS
REFERENCES : 1 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299
STANDARDS :
TOOLS/EQUIP :
SKILLS/KNOWLEDGE:

111111111101 — LOCATION OF TUNE-UP INFORMATION FOR A 1979 CIVIC OR CVCC IN THE REPAIR MANUAL

111111111102 — LOCATION OF SPARK PLUGS

333333333301 — ABILITY TO INTERPRET AUTO TUNE-UP PROCEDURES (INSTRUCTIONS FOR THE JOB FUNCTION)

TERMINATING CUE(S):
I ALL SPARK PLUGS ARE REMOVED FROM THE ENGINE

OUTPUT:
I PLUGS ARE REMOVED FROM ENGINE

STANDARDS:
I IN ACCORDANCE WITH REPAIR MANUAL

CONSEQUENCES OF INADEQUATE PERFORMANCE:
I FOREIGN MATTER ENTERS CYLINDERS AND CAUSES SEVERE DAMAGE
2 BURNS RESULT FROM HOT ENGINE

HUMAN INTERFACES:
1 SUPERVISOR

PERSONNEL SAFETY CONSIDERATIONS:
I BURNS CAN RESULT FROM TOUCHING A HOT ENGINE

GENERAL REFERENCES:
I 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299

GENERAL TOOLS AND EQUIPMENT:
1 MASKING TAPE
2 13/16 IN. SPARK PLUG SOCKET
3 SPARK PLUG WRENCH
4 LINT FREE CLOTH

JOB PERFORMANCE MEASURE REPORT 08/31/85

JOB CLASSIFICATION: JPM FOR TASK NO: 1000010101

TASK TITLE: REMOVE SPARK PLUGS

A. CONDITIONS: (INDICATE PLANT MODE, EQUIPMENT AND EQUIPMENT STATUS, TOOLS AND MATERIALS, REFERENCES, ETC., THAT AID IN TASK PERFORMANCE)

1 ENGINE MUST BE COOL TO THE TOUCH

REFERENCES:

1 2 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299

TOOLS AND EQUIPMENT:

1 8 MASKING TAPE
2 11 13/16 IN. SPARK PLUG SOCKET
3 12 SPARK PLUG WRENCH
4 22 LINT FREE CLOTH

B. STANDARDS: THE TRAINEE MUST SATISFACTORILY MEET THE FOLLOWING MINIMUM ACCEPTABLE STANDARDS

1 WORK ORDER FOR TUNE-UP SIGNED BY CUSTOMER AND SUPERVISOR

C. TRAINEE CHECKLIST

TASK ELEMENT:	CRITICALITY/ SEQUENCE CODE(NOTE)*
1 MARK EACH SPARK PLUG WIRE WITH A PIECE OF MASKING TAPE AND NUMBER IT ACCORDING TO ITS CORRESPONDING CYLINDER.	C

REFERENCES:

1 2 1979 HONDA CIVIC/CVCC REPAIR MANUAL ISBN 0-8019-7473-9, PG 288,296-299

SURVEY RESULTS:

TEST AND EVALUATION PRACTICES

PRESENTED AT T&E SUB-TAG
5 NOVEMBER 1985
SAN DIEGO, CALIFORNIA

DR. DAVID MEISTER
NAVAL PERSONNEL RESEARCH AND DEVELOPMENT CENTER

PURPOSES FOR WHICH TESTING IS ACCOMPLISHED RANKED IN ORDER OF IMPORTANCE

	RANK OF RANKS	MEAN RANKS
TO COMPLY WITH GOVERNMENT REGULATIONS	8	5.06
TO DETERMINE THAT THE SYSTEM CAN BE OPERATED/MAINTAINED EFFECTIVELY BY PERSONNEL	1	1.47
TO DISCOVER HUMAN ENGINEERING DESIGN INADEQUACIES	2	2.80
TO DETERMINE WHICH ONE OF TWO OR MORE DESIGN CONFIGURATIONS IS MOST EFFECTIVE	5.5	4.88
TO VERIFY THAT TRAINING IS EFFECTIVE.	4	4.6
TO DETERMINE THAT SYSTEM CHANGE MADE SYSTEM MORE EFFECTIVE	5.5	4.88
TO DISCOVER THE EFFECT OF VARIABLES AFFECTING SYSTEM OPERATION	7	4.94
TO INVESTIGATE AND RESOLVE SYSTEM PROBLEMS	3	3.94
TO INVESTIGATE RESEARCH VARIABLES	9	8.0

FREQUENCY OF METHOD USAGE

METHOD	OVERALL RANK	PERCENTAGE REPORTING "USED CONSTANTLY" OR "VERY OFTEN"
TEST PLAN	1.5	90
QUESTIONNAIRES	1.5	91
INTERVIEWS	4.5	85
OBSERVATION	4.5	85
OPINION SURVEY	4.5	85
RATING SCALES	4.5	85
CHECKLISTS	7	65
ENVIRONMENTAL TESTS (e.g., SOUND, LIGHT, TEMPERATURE)	8	45
WALKTHROUGHS	10.5	36
ACTIVITY ANALYSIS	10.5	37
COMPUTERIZED METHODS	10.5	37
AUTOMATED DATA RECORDING	10.5	37
PHOTOGRAPHIC TECHNIQUES	14	34
TAPE RECORDING	14	33
CRITICAL INCIDENTS	14	33
ATTITUDE MEASUREMENT	16.5	25
ACCIDENT INVESTIGATION	16.5	25
PHYSIOLOGICAL DATA RECORDING	18	20
DYNAMIC MOCKUPS	19	10
DISPLAY EVALUATIVE INDEX	20.5	5
STATIC MOCKUPS	20.5	4

METHOD USEFULNESS

METHOD	OVERALL RANK	PERCENTAGE REPORTING "INDISPENSABLE" OR "VERY USEFUL"
OBSERVATION	1	100
TEST PLAN	2.5	82
INTERVIEWS	2.5	80
DYNAMIC MOCKUP	4	76
QUESTIONNAIRES	5	70
CHECKLISTS	6	67
RATING SCALES	8.5	62
AUTOMATED DATA RECORDING	8.5	60
PHOTOGRAPHIC TECHNIQUES	8.5	61
ENVIRONMENTAL TESTS (e.g., SOUND, LIGHT, TEMPERATURE)	8.5	62
OPINION SURVEY	11	57
STATIC MOCKUPS	12.5	53
ACTIVITY ANALYSIS	12.5	52
ACCIDENT INVESTIGATION	14.5	52
COMPUTERIZED METHODS	14.5	50
WALKTHROUGHS	16.5	35
TAPE RECORDING	16.5	33
CRITICAL INCIDENTS	18	28
PHYSIOLOGICAL DATA RECORDING	19	19
ATTITUDE MEASUREMENT	20	13
DISPLAY EVALUATIVE INDEX	21	0

METHOD EASE OF USE

METHOD	OVERALL RANK	PERCENTAGE REPORTING "USED CONSTANTLY" OR "VERY OFTEN"
CHECKLISTS	1	80
QUESTIONNAIRES	2.5	75
RATING SCALES	2.5	76
OPINION SURVEY	4	66
WALKTHROUGHS	5.5	63
PHOTOGRAPHIC TECHNIQUES	5.5	62
INTERVIEWS	7.5	59
ENVIRONMENTAL TESTS (e.g., SOUND, LIGHT, TEMPERATURE)	7.5	57
CRITICAL INCIDENTS	9.5	42
TAPE RECORDING	9.5	42
OBSERVATION	11.5	39
ATTITUDE MEASUREMENT	11.5	39
STATIC MOCKUPS	13	37
TEST PLAN	14.5	32
AUTOMATED DATA RECORDING	14.5	33
DISPLAY EVALUATIVE INDEX	16	22
ACCIDENT INVESTIGATION	17	20
COMPUTERIZED METHODS	19	16
PHYSIOLOGICAL DATA RECORDING	19	16
ACTIVITY ANALYSIS	19	15
DYNAMIC MOCKUPS	21	10

FACTOR CORRELATIONS

	Rho	SIGNIFICANCE
FREQUENCY X UTILITY	.70	.01
FREQUENCY X EASE	.62	.01
UTILITY X EASE	.01	NS

SERIOUSNESS OF PROBLEM AREAS (PERCENT REPORTING)

	VERY SERIOUS/ IMPORTANT	CRITICALLY SERIOUS/ IMPORTANT	RANK
MONEY CONSTRAINS	24	24	7
SCHEDULE CONSTRAINTS	19	66	1
NEGATIVE MANAGEMENT ATTITUDES TOWARD HF	19	9	14
NEGATIVE SUBJECT ATTITUDES	14	9	10.5
INSUFFICIENT NUMBER OF SUBJECTS	38	19	4
TOO FEW TEST TRIALS	52	24	3
HF SUBORDINATED TO EQUIPMENT ASPECTS	43	28	2
DIFFICULTY IN APPLYING PREFERRED MSMT TECHNIQUE	52		5.5
CRAMPED TEST ENVIRONMENT	19	4	10.5
LACK OF SUPPORTING PSYCHOLOGICAL DATA	43		8
TOO FEW DATA COLLECTORS	9	9	15
MEASUREMENT METHODS INADEQUATE	33	19	5.5
LACK OF NECESSARY TECHNICAL DATA	19	19	9
EQUIPMENT CONFIGURATION KEEPS CHANGING	10	20	12.5
REPEATED EQUIPMENT MALFUNCTIONS	25	5	12.5

CRITERIA USED TO EVALUATE THE SUCCESS OF A HUMAN PERFORMANCE TEST

	MEAN RANK
DISCOVERED HUMAN ENGINEERING DESIGN DISCREPANCIES	2.95
SATISFIED TEST/DEVELOPMENT MANAGEMENT	4.35
MADE QUANTITATIVE PREDICTIONS OF OPERATOR PERFORMANCE	3.52
FORMAL TEST REPORT PUBLISHED	5.55
BEST ONE COULD GET UNDER THE CIRCUMSTANCES	3.5
TEST LED TO MORE EFFECTIVE DESIGN CONFIGURATION	1.75
TEST RESULTS HAD RESEARCH IMPLICATIONS	6.1

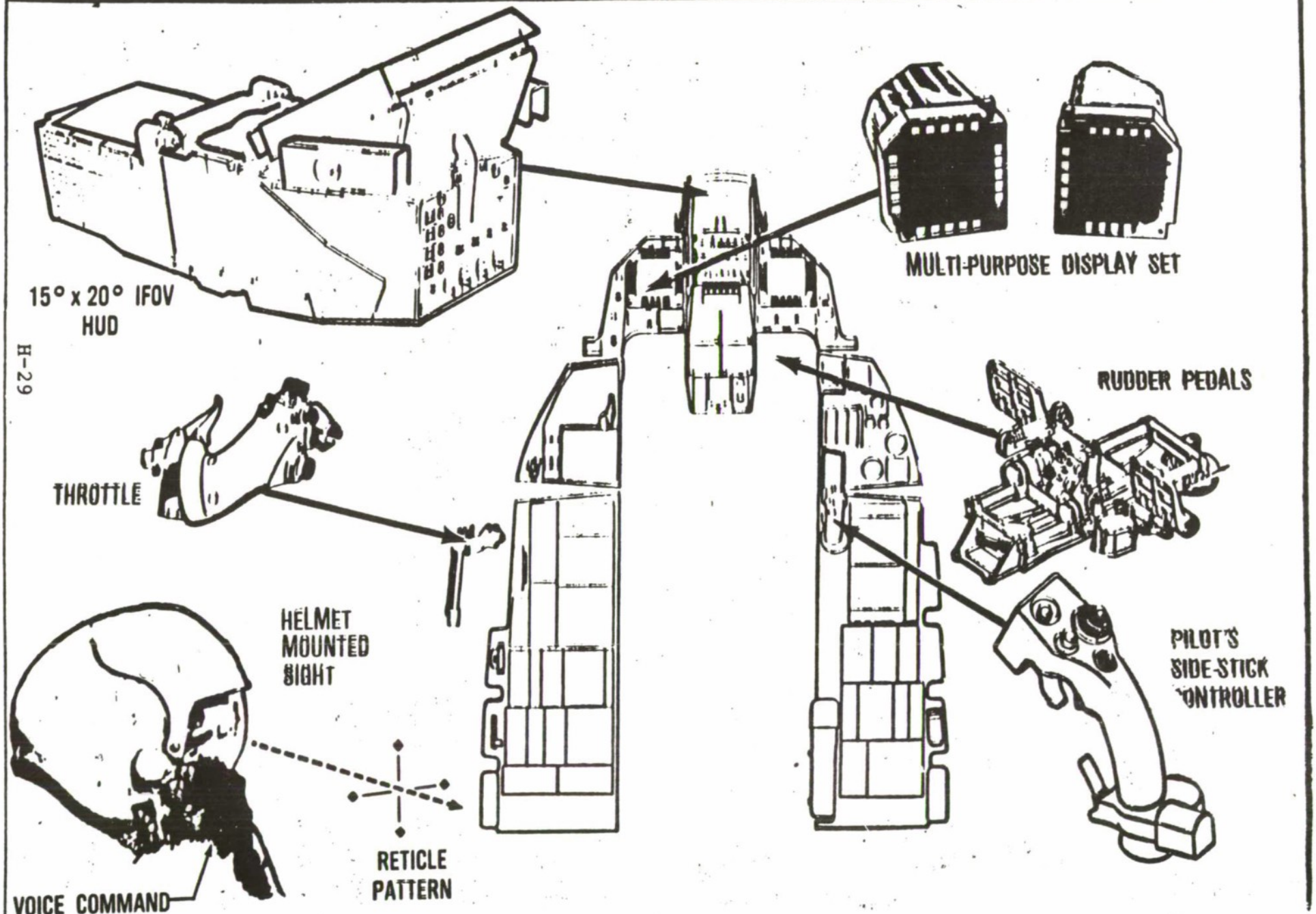
FREQUENCY WITH WHICH STATISTICAL TECHNIQUES ARE USED

	VERY OFTEN USED	CONSTANTLY USED	RANK
FREQUENCY MEASUREMENTS, e.g., MEAN, MEDIAN	52%	38%	1
NON-PARAMETRIC STATISTICS	42%	9%	2
ANALYSIS OF VARIANCE (ALL VARIETIES)	38%	0	3
CENTRAL-COMPOSITE DESIGN	4%	0	8.5
ANALYSIS OF CO-VARIANCE	5%	0	7
CORRELATION	29%	4%	4
FACTOR ANALYSIS	4%	0	8.5
MULTIPLE REGRESSION ANALYSIS	10%	0	6
"t" - TESTS	20%	0	5

AFTI/F-16 Data From 1553 Data Bus

Test and Evaluation
Sub-Tag
Nov 85

Janice R. Stoliker
6520 TG/ENAH, Stop 239
EAFB, CA


15° x 20° IFOV
HUD
MULTI-PURPOSE DISPLAY SET
RUDDER PEDALS
THROTTLE
HELMET
MOUNTED
SIGHT
PILOT'S
SIDE-STICK
CONTROLLER
RETICLE
PATTERN
VOICE COMMAND

PROGRAM OBJECTIVES

1. ASSESS THE ADEQUACY OF THE PILOT-VEHICLE INTERFACE (PVI)

2. IDENTIFY AND DEVELOP THE METHODOLOGIES AND TEST INSTRUMENTATION FOR DETERMINING PILOT PERFORMANCE AND WORKLOAD ASSOCIATED WITH AFTI/F-16 TECHNOLOGIES

3. QUANTIFY WORKLOAD BY ASSESSING PILOT PERFORMANCE IN A/A AND A/G TARGET TRACKING IN AUTOMATED AND MANUAL MODES

TEST METHODOLOGY

- ESTABLISH CONTROL AND PERFORMANCE PARAMETERS FOR MANUAL AND AUTOMATED TARGET TRACKING
- BIOMED INSTRUMENTATION
- 1553 DATA BUS
- SWAT SCORES

CONTROL AND PERFORMANCE PARAMETERS FOR A/A AND A/G TRACKING AUTOMATED AND MANUAL

CONTROL	PERFORMANCE
PITCH	DISTANCE OF PIPPER FROM TARGET
ROLL	AIRSPEED
THROTTLE TWIST	ALTITUDE
AZ, EL BIAS COMMAND	

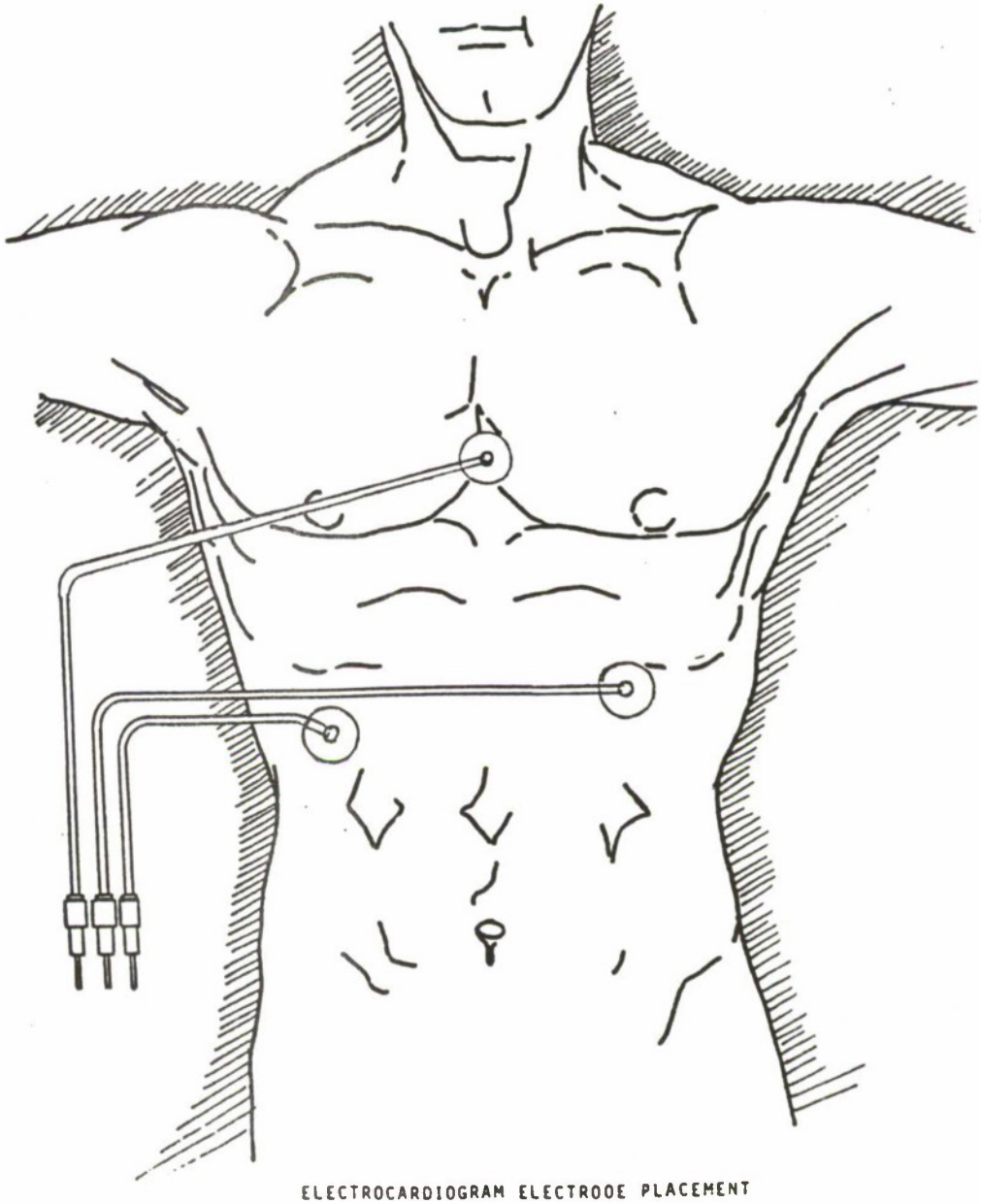
- AUTOMATED DELIVERIES - PILOT BLENDING WILL BE EVALUATED

BIOMEDICAL INSTRUMENTATION

* DESIGNED AND BUILT BY USAFSAM

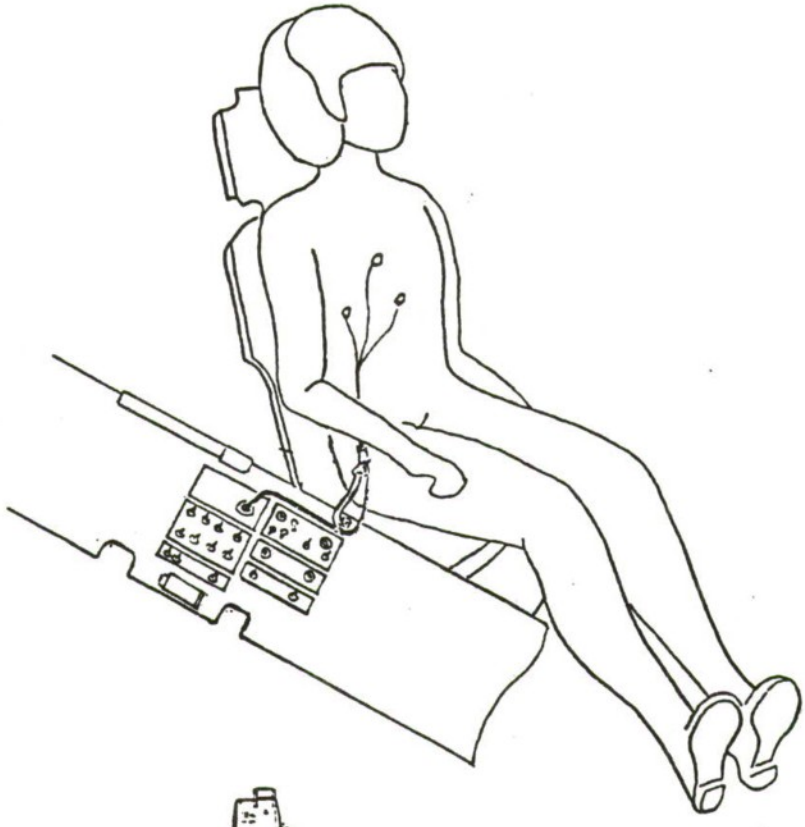
* CURRENTLY COLLECTING EKG DATA
  - HEART RATE
  - HEART RATE VARIANCE

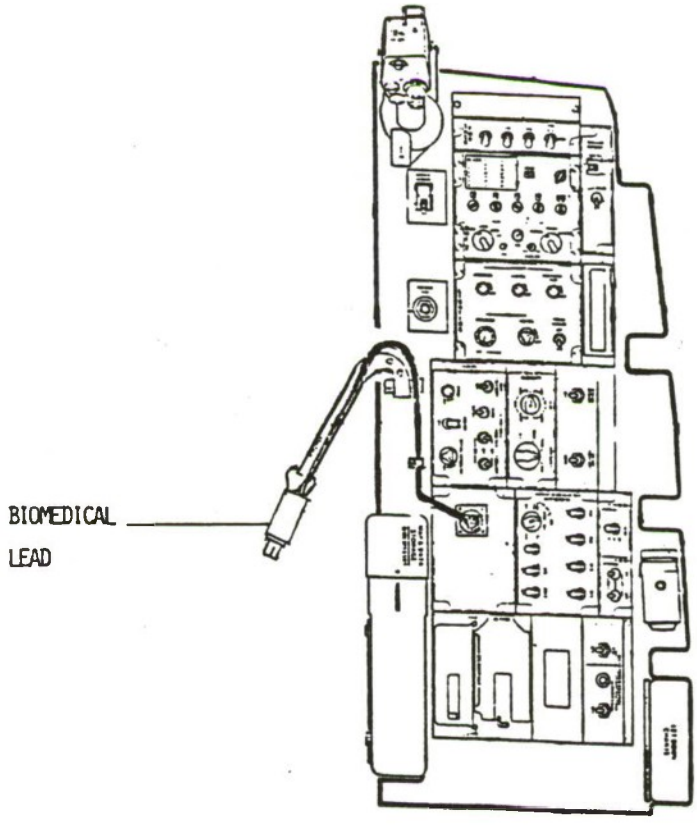
* BIOMED BOX CAN BE MODIFIED FOR:
  - EMG
  - EEG
  - EYE BLINK



ELECTROCARDIOGRAM ELECTROOE PLACEMENT

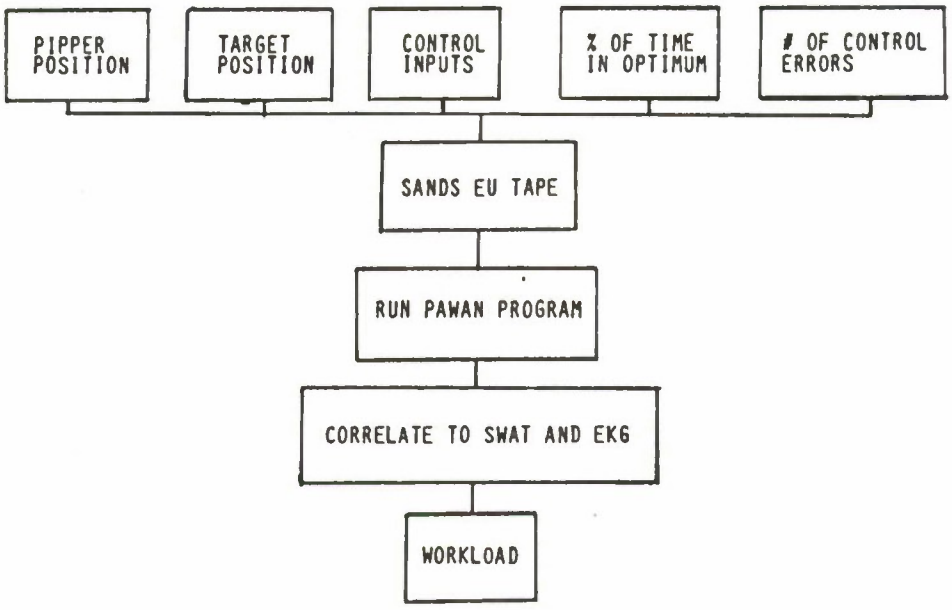
PILOT SEAT INTERFACE

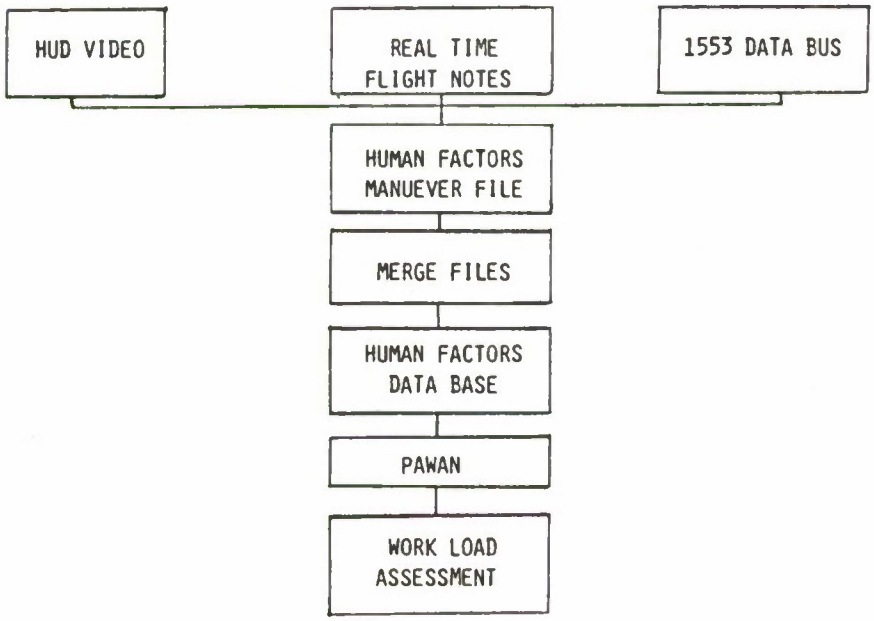




RIGHT HAND CONSOLE

1553 DATA BUS





SUMMARY

- AFTI/F-16 HIGH WORKLOAD ENVIRONMENT
- DETERMINE PILOT PERFORMANCE AND ASSESS WORKLOAD THROUGH THE USE OF:
  - CONTROL AND PERFORMANCE PARAMETERS
  - BIOMEDICAL DATA
  - SWAT SCORES
  - 1553 DATA BUS

INTERACTION BETWEEN T&E SUB-TAG AND THE HUMAN FACTORS SOCIETY TEST AND EVALUATION TECHNICAL GROUP

PRESENTED AT T&E SUB-TAG
5 NOVEMBER 1985
SAN DIEGO, CALIFORNIA

MR. TOM ENDERWICK
NAVAL PERSONNEL RESEARCH AND DEVELOPMENT CENTER

HUMAN FACTORS SOCIETY

- PARENT ORGANIZATION
- LOCAL CHAPTERS
- TECHNICAL GROUPS

TEST AND EVALUATION TECHNICAL GROUP

- BACKGROUND
- HUMAN FACTORS SOCIETY
- PURPOSE OF T&E TECHNICAL GROUP
- RELATIONSHIP WITH T&E SUB-TAG

THE TEST AND EVALUATION TECHNICAL GROUP

OF

THE HUMAN FACTORS SOCIETY

PURPOSE

The purpose of this Technical Group is to promote and foster research and technology to improve informal and formally scheduled tests whose purpose is to assess human performance with and without direct interaction with other people, the environment, systems and/or equipment. Areas of measurement include personnel organization, task organization, skill requirements, life support systems, task performance, training effectiveness, biomedical factors, etc. Testing may involve any type of observation and measurement of task performance utilizing recording devices, observer personnel and subjective responses during the design preparation, operation, and maintenance of systems.

THE TEST AND EVALUATION TECHNICAL GROUP

OF

THE HUMAN FACTORS SOCIETY

ACTIVITIES

The activities to be pursued by the Technical Group include:

- o Participating in the Human Factors Society Annual Meeting technical program
- o Encouraging and aiding in the development, validation, and application of methodologies, techniques, and procedures to enhance the reliability, validity and utility of test results
- o Engaging and aiding in the review and production of manuals, handbooks, and texts that contribute to a human factors knowledge base of test and evaluation
- o Seeking to promote interest in and funding for human factors test and evaluation in industry, government, and academia
- o Establishing and maintaining liaison with other Human Factors Society technical groups and other professional societies and associations
- o Reporting of activities and items of interest to the membership, through the publication of a newsletter at least twice a year
- o Sponsoring special meetings and symposia.

ATTACHMENT I

MANNED SYSTEM MODELING -- CHARTER

AND VIEW GRAPHS

November 8, 1986

CHARTER OF THE MANNED SYSTEM MODELLING SubTAG

Origin:

Established as an ad hoc committee to the TAG, May 1981. Converted to full SubTAG status in 1983.

Objectives:

The Manned System Modelling SubTAG was established to provide a mechanism for the exchange of technical information and the identification of points of contact within the DoD, civilian agencies, and affiliated organizations, and to increase government personnel awareness of the state-of-the art in the representation of Human Behavior/Function in complex systems by formal structures.

Scope:

The technical scope of the SubTAG includes the full spectrum of manned system simulation tools, representational formats, and processing languages. Included within this scope are network, stochastic, control theory, bionic models, AI data structures, and knowledge based machine representation formats. Application areas include individual, team, and integrated multi-weapon system problem areas.

Membership Policy:

Open to any DoD, NASA, other federal agencies, and Technical or Industrial representatives,(by invitation), working in the area of manned system simulation as defined above and consistent with the policies of the DoD HFE TAG.

Chairperson:

Chairpersons are to be elected from the active membership of the SubTAG for a two year term. The first year will be as chair elect and requires working with the current chair, attending TAG operating board meetings, and assisting with the selection of speakers in support of future meetings. During the second year, the chair elect will assume full responsibility for the

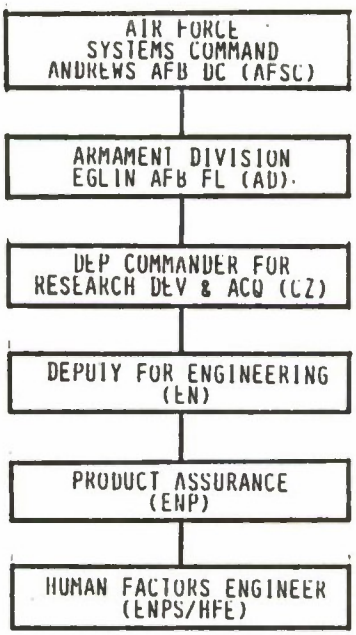
SubTAG activities and will preside over the election of the next chair who will in turn assume full duties at the end of the second year. It is the intent of the rotation sequence that there will always be at least one available chair for all TAG or SubTAG meetings, and at least one year of experience will have occurred before a chair elect assumes full responsibility.

Meeting Schedule:

The normal meeting schedule will be coincident with the main TAG. This schedule may be changed at the discretion of the Chairman to include meetings outside the TAG. The SubTAG will meet at least once a year with the main TAG regardless of additional outside meetings.

- A HUMAN FACTORS ENGINEERING (HFE) NEED OF AIR FORCE ARMAMENT DEVELOPMENT (AFSC/AD)
  - AN HFE DESIGN STANDARD THAT INCLUDES AWARENESS/SYSTEMS INTERFACES
- IN RESPONSE TO AFR 800-15, AFSC SUP 16.9(H) "THE (HFE) OPR WILL: IDENTIFY RESEARCH AND TECHNOLOGY GAPS OR DEFICIENCIES THAT CANNOT BE IMMEDIATELY ALLEVIATED"
- DRAFT PRESENTATION TO THE MANNED/SYSTEM MODELING SUB-TAG OF THE DOD HFE TAG

J. JONES, ENGINEERING PSYCHOLOGIST, HFE OPR
AD/ENP, EGLIN AFB FL 32542-5000
AV 872-8652, (904) 882-8652



- AN HFE APPLICATIONS PERSPECTIVE

  - HFE NEEDS AT PRODUCT DIVISIONS COULD BE SOLICITED BY RESEARCHERS, AND/OR

    -- HFE NEEDS COULD BE PRESENTED TO THE APPROPRIATE DOD HFE SUB-TAG FOR COMMENTS/EVALUATION PRIOR TO FORMAL RESEARCH FUNDING REQUEST.
    -- THIS INFORMAL TWO-WAY INTERACTION COULD GENERATE/STIMULATE PRODUCTIVE INNOVATION.
    -- THIS PRESENTATION IS A TRIAL EXAMPLE, IT ASKS

      --- HAVE THE APPROPRIATE PARAMETERS OF COGNITION, TASKS, AND ENVIRONMENTS BEEN IDENTIFIED FOR USE IN MANNED/SYSTEMS MODELS FOR ARMAMENT DIVISION PRODUCTS?

- EXAMPLE PROBLEM-GRDCOS, RCS, AMRAAM: GULF RANGE DRONE CONTROL UPGRADE SYSTEM, RANGE CONTROL SYSTEM, AND AMRAAM MISSILE: 3 NEW INTERACTING SYSTEMS

  - CONTROL ROOMS FULL OF CONSOLES AND LARGE SCREEN DISPLAYS
  - PILOTS FLYING MILES OUT OVER THE GULF FIRING A NEW MISSILE UNDER DEVELOPMENT
  - AIRBORNE CREW SPOTTING BOATS IN THE AREA AND ACTING AS A TELEMETRY AND AUDIO COMMUNICATIONS LINK
  - PEOPLE AT CONSOLES FLYING DRONE TARGETS
  - SAFETY OFFICERS, ANALYSTS AND REAL TIME COMPUTER SOFTWARE INTERACTING
  - QUESTION: HOW DOES HFE MODEL THESE NEW SYSTEMS BEFORE CDRs TO EVALUATE ALL INTERACTIONS?
  - WITH A MODEL WHAT COGNITIVE PARAMETERS ARE INPUT-IQ, A BIG SHORT TERM MEMORY, ANY PILOT WILL DO TO FLY DRONE, AN INTUITIVE EXTROVERTED INTROVERT AS TROUBLESHOOTER?
  - WHAT INFORMATION AND PRESENTATION ALTERNATIVES WORK BEST WITH WHAT PEOPLE AND MISSION PARAMETERS?
  - HOW DO WE MODEL DECISION-MAKING, PEOPLE RELIABILITY, STRESS, WORKLOAD DISTRIBUTION, ETC., IN ASSOCIATION WITH LARGE SYSTEMS?

- AN AWARENESS/SYSTEM INTERFACE
  - IS THE SUBSET OF A MANNED/SYSTEMS MODEL, THAT
  - IS ANCILLARY TO THE COGNITIVE/TASK/ENVIRONMENT MODEL, THAT
  - INCLUDES BIOLOGICALLY BIASED AND OTHERWISE PREDISPUSED INDIVIDUAL AND GROUP AWARENESS SIYLE RESPONSES TO TASK/ENVIRONMENT PERFURMANCE SHAPING FACTURS.

- AN AWARENESS/TASK/ENVIRONMENT TAXONOMY
  - WUULD PROVIDE ALIGNMENT OF PERSONNEL SKILL SELECTIUN DEVICES TO NATURAL COGNITIVE OR AWARENESS CONTINUUMS, EXISTING MANPOWER POOLS, AND TO DESIGN PARAMETERS UF SYSTEMS.
  - WUULD BRUADEN PRESENT FOCUS IN COGNITIVE STUDIES FROM DECISION MAKING PROCESSES INVOLVING LONG AND SHORT TERM MEMORY, ANALYTIC-INTUITIVE INDUCING ASPECTS UF THE PROBLEM DOMAIN, THE MECHANICS OF PATTERN RECUGNITION PRUCESSES, ETC., TO SYSTEMATIC BIASES OF ANTICIPATION, BELIEFS, VALUES, MOTIVATIONS, NEED STRUCTURE, ETC., AND THEIR EMOTIVE POWER TU BIND OR REPEL PERSONNEL TYPING PARAMETERS AFFECTING EFFICIENCY, RELIABILITY, MUTIVATION, LEARNING, ETC.

- AN AWARENESS/SYSTEM INTERFACE MODEL
  - WOULD PROVIDE A TAXONOMY UF TASK AND WORK PLACE CHARACTERISTICS THAT SENSITIZES AWARENESS ELEMENTS IN A TAXONOMY OF NATURAL CONTINUUMS SIGNIFICANT TO INDIVIDUAL DIFFERENCES, E.G. SENSORY-MOTOR TASK ELEMENT THAT SENSITIZES A SPECIFIC REGION OF A SENSORY - INTERNAL OR CONCRETE-ABSTRACT AWARENESS CONTINUUM THAT ALSO ALIGNS AND DEFINES NATURAL PERSUNNEL "TYPE" PREFERENCES IN TASK/ENVIRONMENT CHARACTERISTICS.

APPRUACH

- REVIEW LITERATURE
  - DISTILL DUD COMMON HFE AWARENESS/TASK/ENVIRONMENT AND PERFORMANCE SHAPING FACTOR MUDEL NEEDS
  - DISTILL A CONSENSUS TAXONOMY OF AWARENESS, TASK AND ENVIRONMENT PARAMETERS
  - EVALUATE MEASUREMENT TECHNOLOGY FOR APPLICABILITY TU THE PARAMETERS
  - EVALUATE APPLICABLE THEURY AND ADVANCE APPARENTLY NEEDED CHANGES
  - DEVELOP MODEL SPECIFICATION CONSISTENT WITH DISTILLED PARAMETERS, MEASUREMENT TECHNOLOGY AND THEURY

CURRENT STATUS

- REVIEWED APPROXIMATELY 200 DOCUMENTS
- TENTATIVE PRIMARY CONTINUUMS: SENSORY-INTERNAL, SELF-OTHER AND TASK/ENVIRONMENT CHARACTERISTICS ALONG NATURAL SENSITIVITIES TO PHYSICAL, LOGICAL, SOCIAL, AND SITUATIONAL/ EMOTIONAL INVARIANTS
- VOCAL SOUND PATTERNS IS THE ONLY PHYSIOLOGICAL MEASUREMENT FOUND SENSITIVE TO ALL THE PARAMETERS THAT IS UNOBTROSIVE, WITH SUFFICIENT VARIABILITY RANGE, UNIVERSAL APPLICABILITY, AND RAPID RESPONSE
- VOCAL DATA ALSO PERTINENT TO MENTAL WORKLOAD AND GENERAL COGNITIVE MODELS
- AVAILABLE VOCAL/AWARENESS DATA APPEARS TO CONFIRM A CONSISTENT THEORY WITH A HEAVY SOCIOBIOLOGICAL EXTENSION
- DRAFT TECHNICAL REPORT AVAILABLE BY END OF 1985

- INVESTIGATOR'S RELATED EXPERIENCE/PUBLICATIONS
  - 5 YEARS HFE, 5 YEARS R&M, 10 YEARS COMPUTER MODELING
  - 5 YEARS MATHEMATICIAN, 2 YEARS NAV AVIATION ELEC MAINT
  - BA MATH, MA PSYCHOLOGY
  - A COMPARISON OF THE FREQUENCIES OF THE PEAK ENERGY OF THE FIRST FORMANT (F1) OF THE SPOKEN VOWEL A FOR TWO OCCUPATIONS-PRESENTED AT THE FALL ACOUSTICAL SOCIETY OF AMERICA MEETING 1979
  - VOCAL DIFFERENCES BETWEEN MEMBERS OF TWO OCCUPATIONS: AN EXAMPLE OF POTENTIAL VOCAL/MENTAL RELATIONSHIPS THAT MAY AFFECT VOICE MEASUREMENT OF PILOT MENTAL WORKLOAD AD-TR-80-57, 1980
  - US PATENT-ORAL SOUND ANALYSIS METHOD AND APPARATUS FOR DETERMINING VOICE, SPEECH AND PERCEPTUAL STYLES, 1984
  - SOUND LANGUAGE AND AWARENESS PSYCHOLOGY, THE SANBIRD PUBLISHING GROUP, 1985, P.O. BOX 1257, SHALIMAR FL 32579 (BOOK)

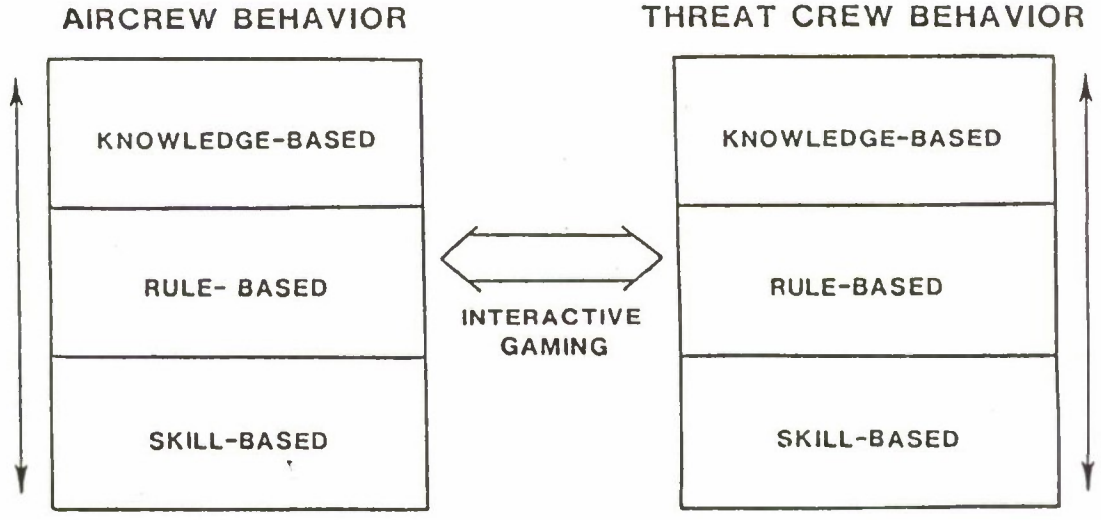
- CONTROL THEORETIC MODELS
- TASK NETWORK MODELING
- RASMUSSEN'S FRAMEWORK
- BLACKBOARD MODELING
- KNOWLEDGE BASED/EXPERT SYSTEM MODELS

AIR FORCE
AEROSPACE MEDICAL RESEARCH LABORATORY

MANNED THREAT QUANTIFICATION PROGRAM



HUMAN PERFORMANCE INTERACTIONS
IN GROUND-AIR ENGAGEMENTS



IDEF/SAINT METHODOLOGY PROVIDES

- STATIC SYSTEM DESCRIPTION
- SYSTEM PERFORMANCE DATA BASE
- DYNAMIC SYSTEM DESCRIPTION

IDEF/SAINT
A POWERFUL COMBINATION

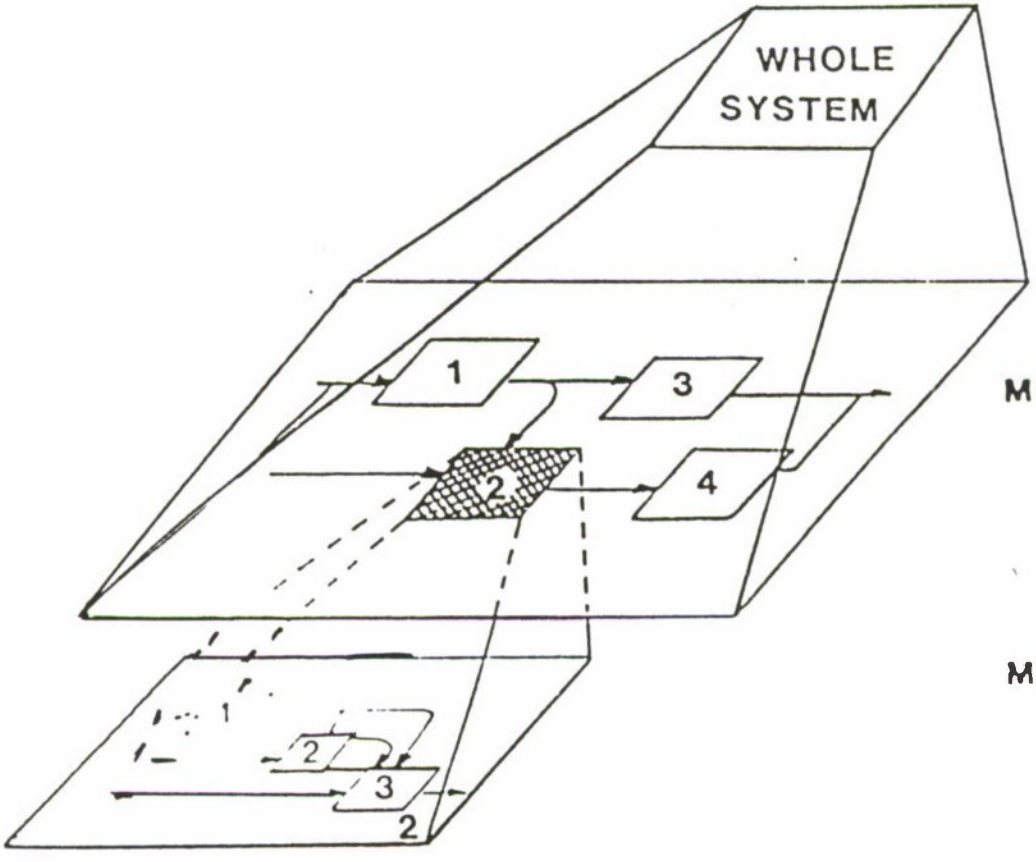
THE IDEF/SAINT SYSTEM CAN BE USED FOR

- M-M SYSTEMS
- REQUIREMENTS DEFINITION
- LARGE COMPLEX SYSTEMS

PROVIDES BETTER

- UNDERSTANDING
- COMMUNICATION
- VALIDATION
- MANAGEMENT
- ANALYSIS
- STANDARDIZATION
- DISCIPLINE

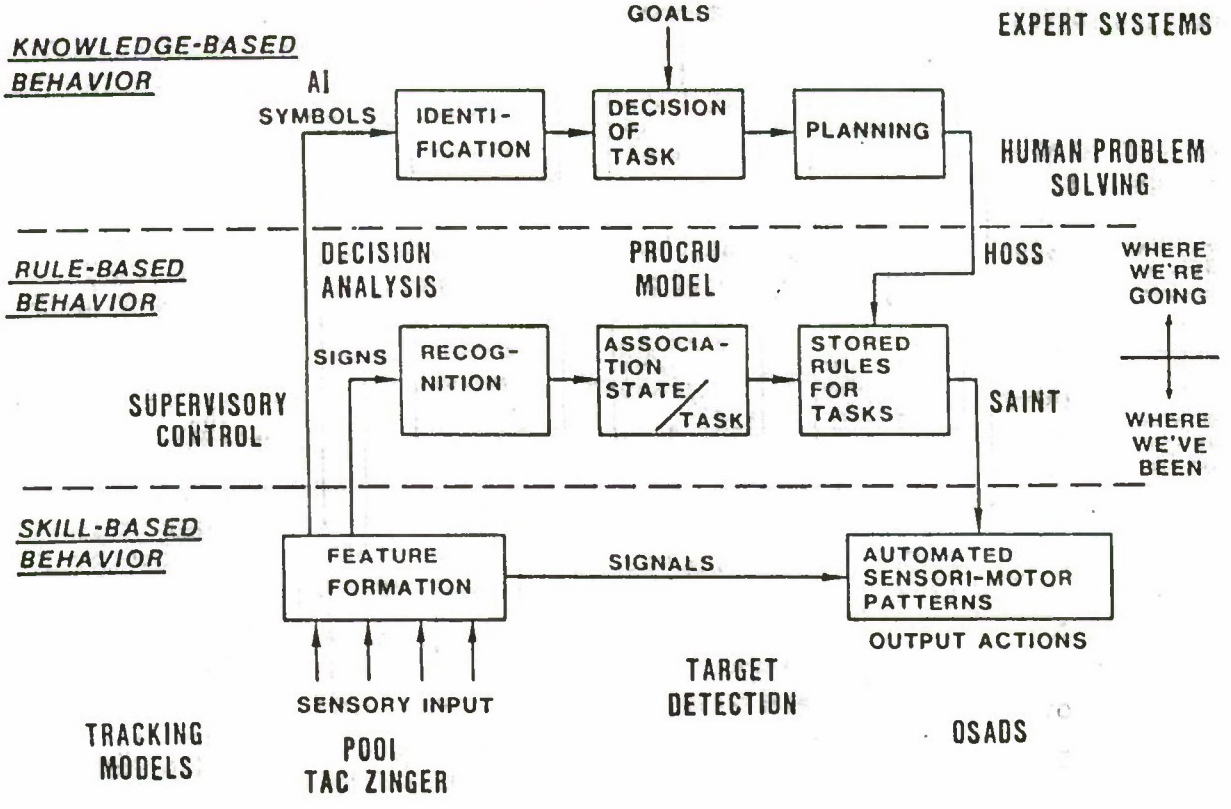
IDEF MODEL



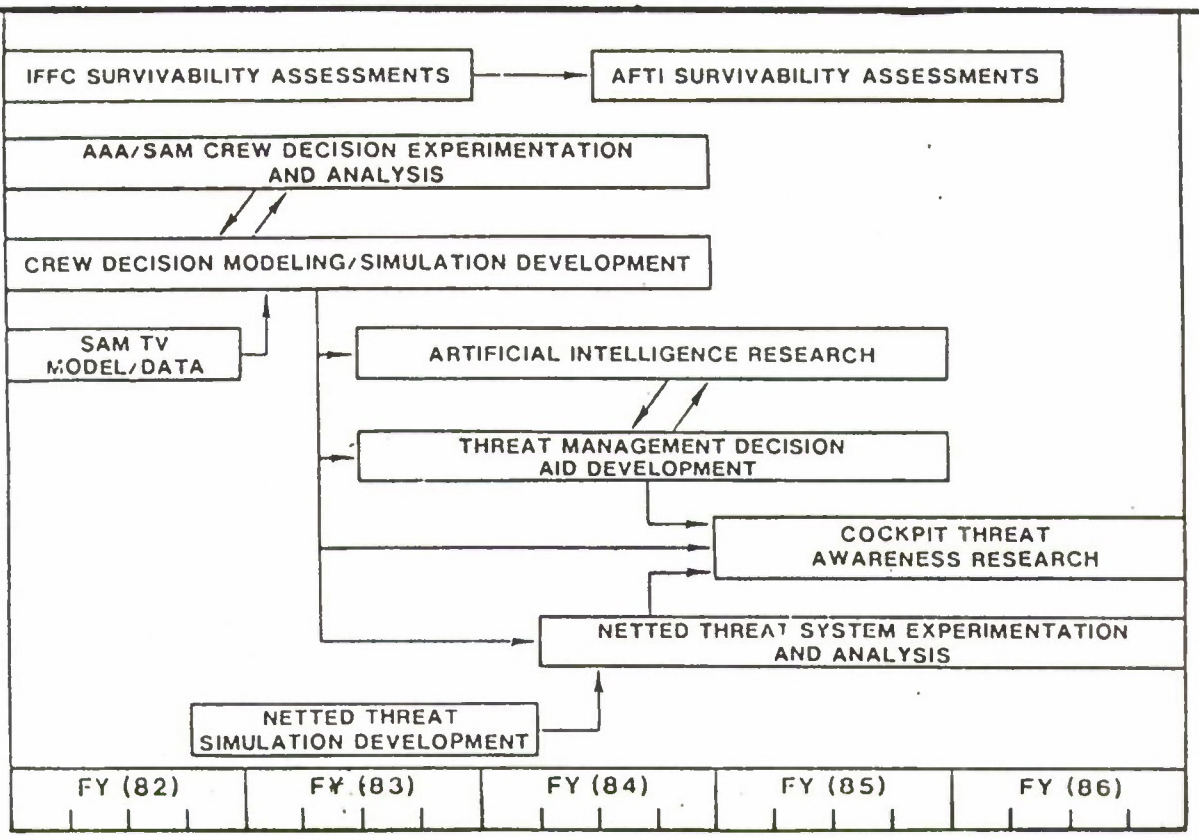
CREW PROCEDURES MODEL

- EXTENSION OF ESTIMATION THEORY AND CONTROL MODELING
- HUMAN DECISION MAKING BASED ON "SCRIPTS"
- RESULTS PROMISING FOR PREDICTING RULE BASED PERFORMANCE
- GOOD STRUCTURE FOR SOVIET CENTRALIZED DECISION-MAKING

A MULTI-LEVEL PROCESS MODEL FOR HUMAN PERFORMANCE



TASK ROADMAP



INTEGRATED ANALYSIS TECHNIQUES

IAT ⟶ ANALYSIS TOOL

1. DESCRIBES THE STRUCTURE OF C^3 MAN-MACHINE SYSTEM
2. REPRESENT THE DYNAMICS OF HUMAN/SYSTEM BEHAVIOR
3. EVALUATE AND PREDICT HUMAN/SYSTEM PERFORMANCE

IAT ⟶ DESIGN TOOL

4. ASSESS WHICH ASPECTS OF A SYSTEM SHOULD BE IMPROVED AND BY HOW MUCH
5. ASSESS WHICH PARTS OF A SYSTEM DESIGN SHOULD BE ALTERED TO ACHIEVE THE DESIRED RESULTS

AUGMENTATIONS

- STUDY COMPLETED
- CANDIDATE TOOLS IN USE OR REVIEWED

- IDEF	- SAINT
- DESCRIPTIVE MATRICES	- FORMAL ANALYTIC STRUCTURES
- FAMILY TREES	- EVENT ANALYSIS
- DIGARPHS	- ENTROPY ANALYSIS
- SHOR PARADIGM	- DATA STRUCTURES
- COUNTING PROCESSES	- AUTOMATIC SYSTEM DECOMPOSITION



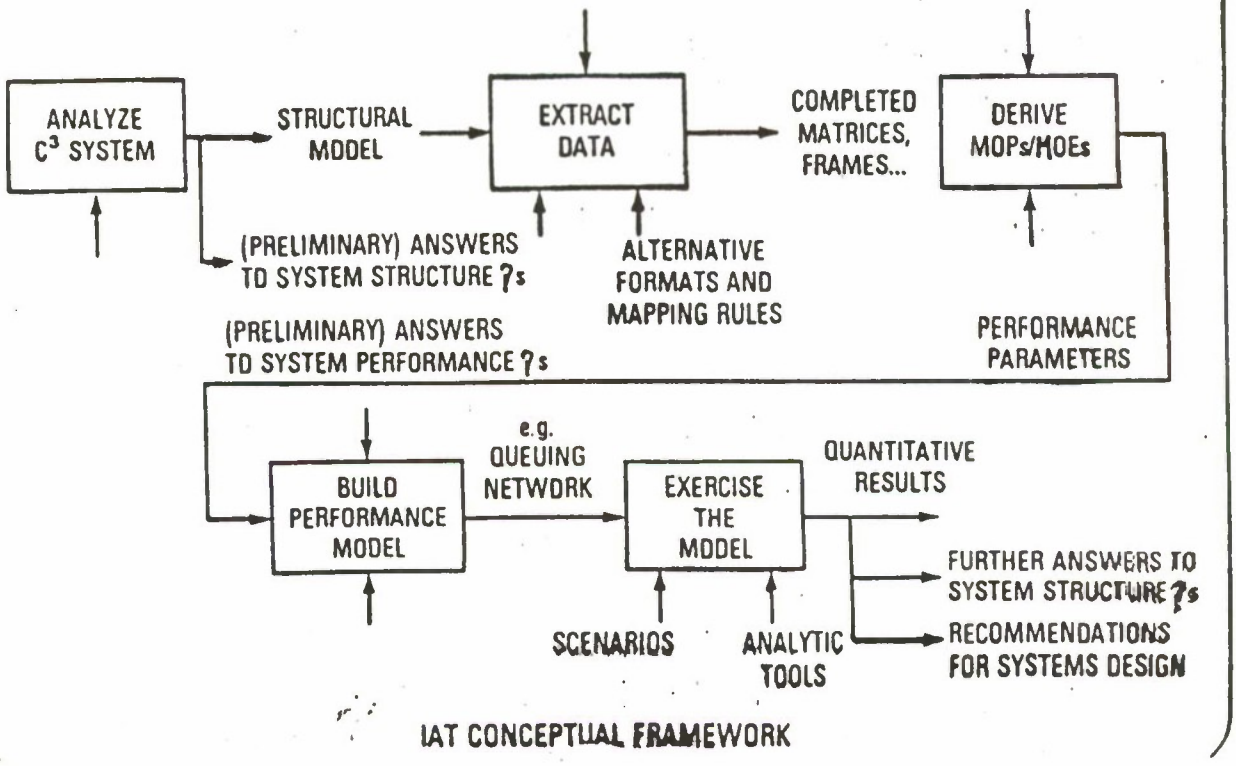
INTEGRATED ANALYSIS TECHNIQUES
IAT



APPROACH

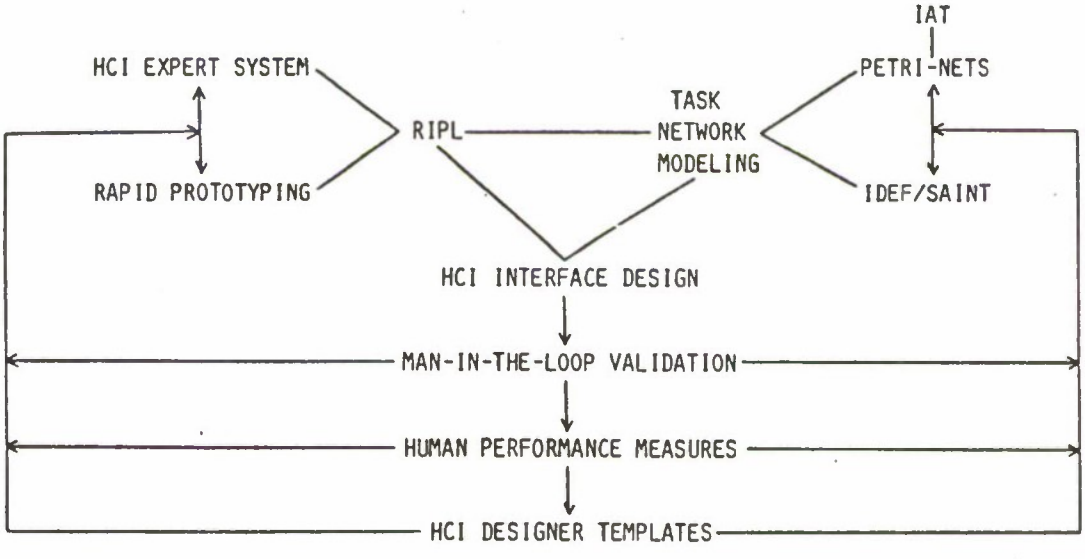
- EMPHASIZE THE HUMAN AS AN INTEGRAL SYSTEM COMPONENT
- DESCRIBE THIS SYSTEM: STRUCTURE, OBJECTIVES, RESOURCES...
- ANALYZE - SYSTEM STRUCTURE
  - SYSTEM PERFORMANCE
- ADDRESS - SYSTEM DESIGN
  - SYSTEM MODIFICATION
- DEVELOP A BATTERY OF TOOLS, HANDBOOK

COPE ACCOMPLISHMENTS
INTEGRATED ANALYSIS TECHNIQUES (IAT)



IAT CONCEPTUAL FRAMEWORK

HCI DESIGNER'S SUPPORT STATION



RIPL

RAPID INTELLIGENT PROTOTYPING LABORATORY



DEFINITION RIPL

Rapid - EASY TO LEARN AND USE

Intelligent - CONTAINS USI GUIDELINE EXPERTISE

Prototyping - SIMULATES THE USI OF AN APPLICATION

Laboratory - A HARDWARE AND SOFTWARE ENVIRONMENT

TECHNICAL APPROACH RIPL

1) EXPERT SYSTEM - RIPL incorporates two expert systems:

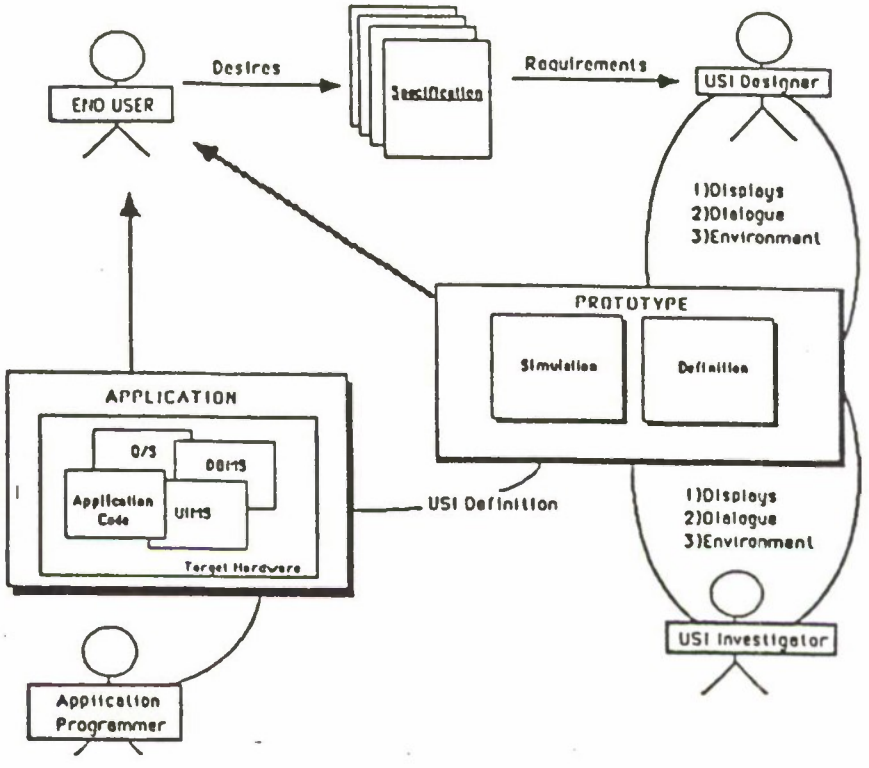
- a Mycin like consultant expert system that responds to general USI information requests (e.g. Tell me about tabular data presentation) ; and
- an evaluation expert system that interprets the current definition of dialogues and displays (e.g. Use of yellow on top of orange is not recommended).

2) KNOWLEDGE BASE - RIPL incorporates the Smith & Mosier guidelines in three ways:

- In a "help by example" facility;
- In the implementation of RIPL(i.e. limit the user's options); and
- In the USI expert systems knowledge base (same rule base for both experts).

3) PROTOTYPE SEMANTICS - RIPL combines a direct manipulation user interface with a graphical ellipsis dialogue interpreter to minimize the prototype and semantic definition overhead.

4) HARDWARE SUITE - Use of the VAX architecture and the GKS standard allows a wide range of upward migration paths for processing power and display capability.



MAJOR FUNCTIONS RIPL

EXECUTIVE

Sets up all necessary file and library accesses.
Performs housekeeping functions of deleting, renaming and backing up RIPL files and libraries.

PROTOTYPE BUILD SUBSYSTEM

Defines screen contents, interactions, and target environment.
Instruments dialogue.

SIMULATION SUBSYSTEM

Compiles simulation components.
Simulates, records, and measures the USI design.

USI ADVISORY SUBSYSTEM

Consults on and/or evaluates design.

TECHNICAL LIBRARIAN

Provides for browsing of guidelines and examples.
Provides help on using RIPL.

INPUT:

1. DISPLAY CONTENT
2. PHYSICAL OPERATING ENVIRONMENT
3. DIALOGUE STRUCTURE
4. SIMULATION PARAMETERS
5. APPLICATION OPERATING ENVIRONMENT

OUTPUT:

1. STRUCTURED DIALOGUE DEFINITION
2. DESIGN CONSULTATION
3. DESIGN EVALUATION
4. DESIGN SIMULATION
5. CAPTURE OF USER INTERACTION DURING SIMULATION
6. INSTRUMENT MEASURES

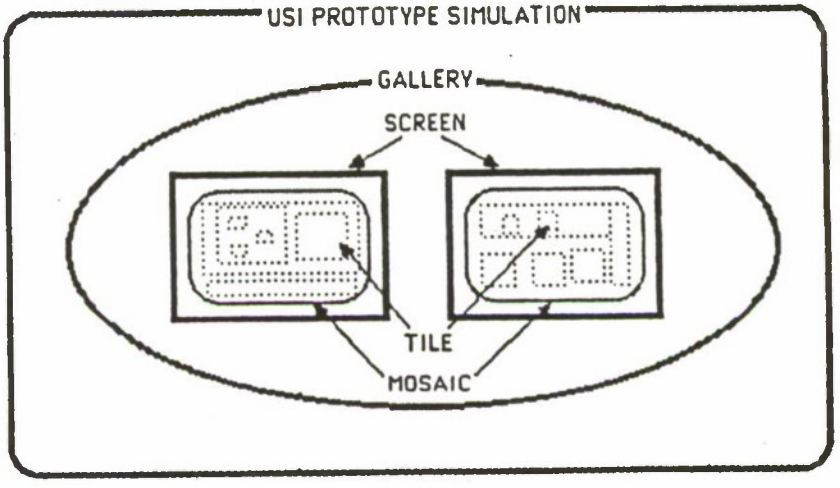
TERMINOLOGY RIPL

STATICS

- o tile - a rectangular area, less than or equal to a screen in a size, having specific attributes and contents. A tile is similar to the graphics term - viewport, except that there is no notion of a larger virtual screen area behind it. Tiles may be grouped in a hierarchy where tiles that are contained in the area defined by larger tiles inherit some of their attributes. The attributes of a tile are dependent on its position in the hierarchy.
- o mosaic - the contents of a user activity screen on a single workstation at any one time. Each mosaic is composed of a hierarchy of tiles.
- o gallery - the collection of all the user activity screens on all displays at any one time.

DYNAMICS

- o thread - a single chain of stimulus-responses originating with the simultaneous activation of a set of tiles.

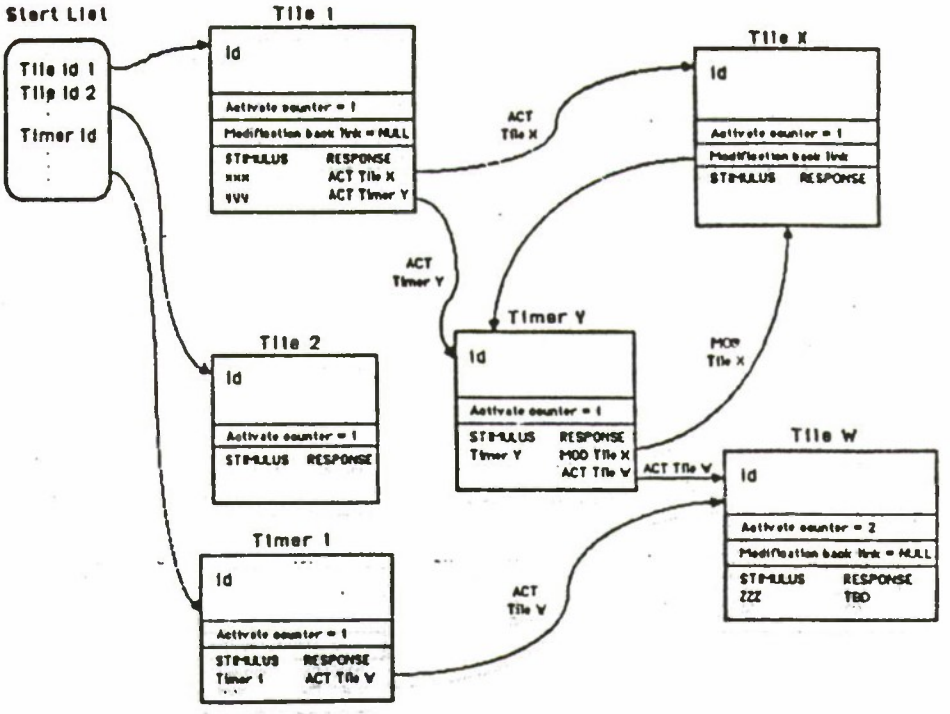


TILE DEFINITION RIPL

- IDENTIFICATION - NAME + ID NUMBER
- CONTENT - (text/table/menu/bit map/display list ...)
- SEMANTIC USE - (error, map, title, status ...)
- LIST OF ATTRIBUTE INSTANCES (position, size, border, view, cursor ...)
- LIST OF CONTENT INSTANCES
- LIST OF STIMULUS-RESPONSES

DIALOGUE THREAD

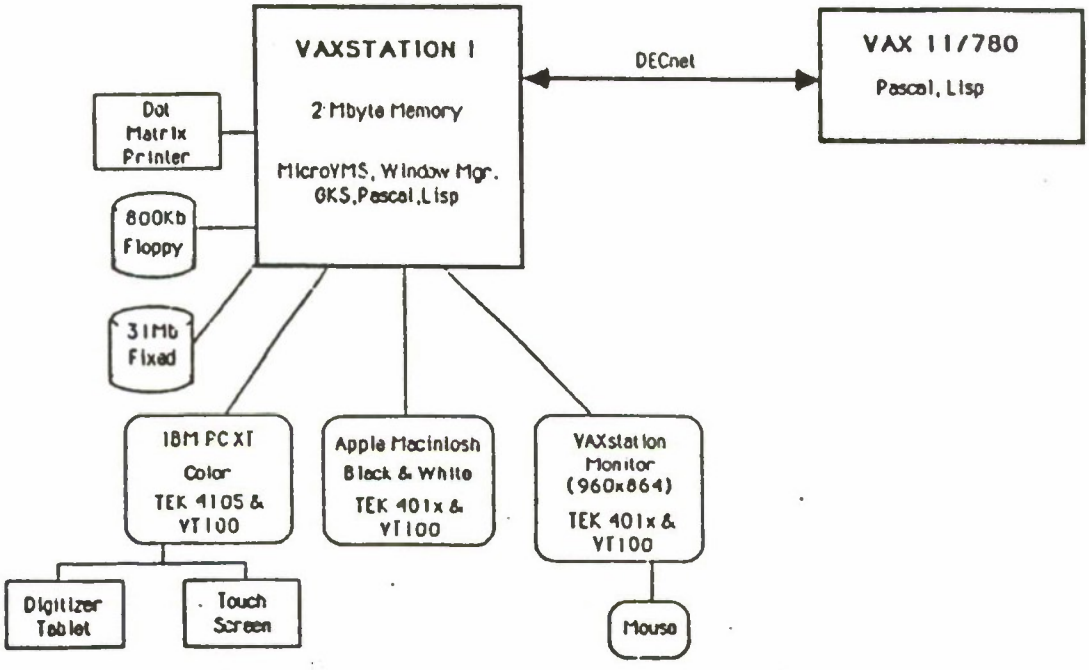
RIPL



RIPL TECHNICAL LIBRARIAN

RIPL

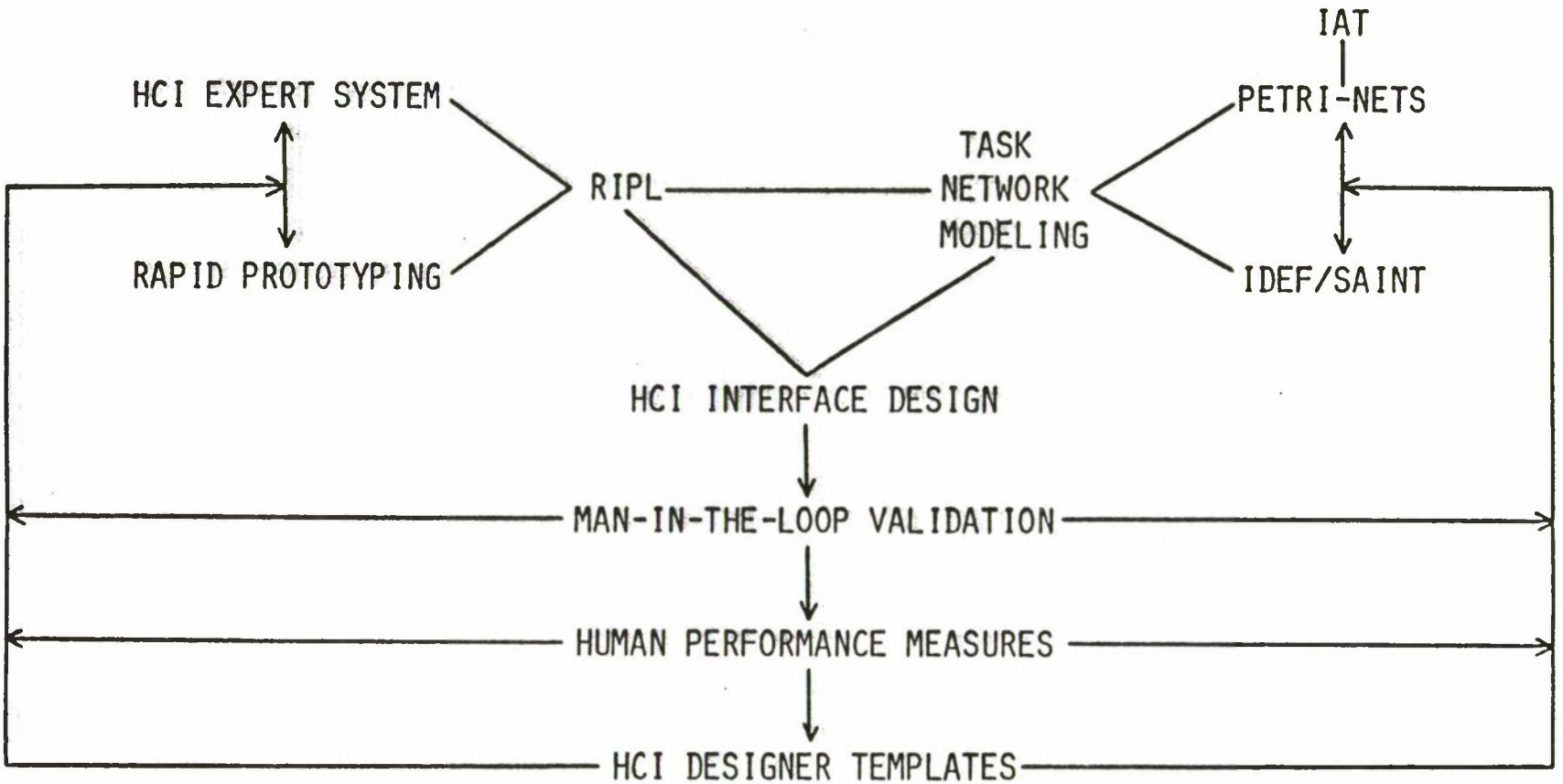
- PROVIDES ON-LINE DOCUMENT ACCESS
- FACILITATES RAPID INFORMATION SEARCH
- FUNCTIONS AS RIPL HELP SYSTEM
- FUNCTIONS AS USI GUIDELINE RETRIEVAL SYSTEM



Approach

1. Select a class of human-computer interaction problems.
2. Develop a standard task for this problem area.
3. Develop several alternative strategies for solving the task
4. Develop task network models for these strategies.
5. Set model parameters via several techniques.
6. Collect laboratory data on subjects performing the tasks using the modeled strategies.
7. Compare model predictions to actual data.

HCI DESIGNER'S SUPPORT STATION



CONFLICT RESOLUTION METHODOLOGY

PROBLEM

- TOTAL KNOWLEDGE CONCEPTS
  - -- MULTIPLE KNOWLEDGE SOURCE TRANSFORMATION
  - -- NO SINGLE "KNOWLEDGE CZAR"
  - -- INTEGRATION OF DISTRIBUTED KNOWLEDGE
- CONTRADICTORY KNOWLEDGE = CONFLICT
  - -- CATASTROPHIC IF NOT RESOLVED
  - -- INCONSISTENCIES
  - -- DEFOCUSSED
- AI MILITARY APPLICATIONS (I.E. AI IN THE COCKPIT)
  - -- EXAMPLE - COCKPIT DECISION AIDING

OBJECTIVES

- CONFLICT RESOLUTION STRATEGIES UNDERSTOOD
  - -- CONCEPTS
  - -- CHARACTERISTICS
  - -- RELATIONSHIPS
- CONFLICT RESOLUTION METHODOLOGY DEFINED
- MODELING TECHNIQUES/TOOLS ESTABLISHED

HUMAN CONFLICT RESOLUTION STRATEGIES

- ACCUMULATE, ACCESS, AND EVALUATE
  - -- EXPERIMENTAL DESIGNS
  - -- CONFLICT RESOLUTION TASKS
  - -- PROTOCOL ANALYSIS
- DEVELOP CONCEPTUAL BASELINE
  - -- OPPORTUNISTIC PROBLEM SOLVING MODEL
  - -- EXPERIMENTAL RESULTS

CONFLICT RESOLUTION METHODOLOGY DEVELOPMENT

- DEVELOP "CONFLICT RESOLVER" MODEL
  - -- DOMAIN INDEPENDENT
  - -- BLACKBOARD ARCHITECTURE BASED (HAYES ROTH, 1979)
  - -- LISP PROCESSOR ENVIRONMENT
- REVIEW KNOWLEDGE ENGINEERING TOOLS/TECHNIQUES
  - -- TOTAL KNOWLEDGE CONCEPT SUPPORT
- DEVELOP COMPREHENSIVE METHODOLOGY
  - -- HUMAN STRATEGIES
  - -- CONFLICT RESOLVER MODEL
  - -- KNOWLEDGE ENGINEERING TOOLS

APPLICATION

- AI MILITARY SYSTEMS
- POTENTIAL USERS
  - -- AI IN ELECTRONIC WARFARE
  - -- C^3 INTELLIGENT WORKSTATION
  - -- COCKPIT AUTOMATION TECHNOLOGY
  - -- PILOT'S ASSOCIATE

ATTACHMENT J

SUSTAINED/CONTINUOUS OPERATIONS -- MINUTES

OF 3 OCTOBER 1985

DEPARTMENT OF THE ARMY
WALTER REED ARMY INSTITUTE OF RESEARCH
WALTER REED ARMY MEDICAL CENTER
WASHINGTON, D.C. 20307

IN REPLY REFER TO:
SGRD-UWI-C

20 November 1985

SUBJECT: Minutes of the 2nd meeting of the Sutained/Continuous Operations SUB TAG: 3 Oct 1985

Department of Defense
Human Factors Engineering
Technical Advisory Group

1. The Sustained/Continuous Operations SUBTAG held its second formal meeting from 0830-1230 on 3 Oct 85 in conjunction with the Human Factors Society Convention in Baltimore, MD. There were 33 attendees. Incl 1 is the agenda and Incl 2 the attendance list.

2. LTC Jerry Krueger, SUBTAG chairman, reviewed for the attendees the short history of the group. Copies of the approved charter, select sustained operations publications and membership mailing list were distributed. Krueger announced the 2nd sustained operations special issue of the journal Behavioral Research Methods, Instruments & Computers will be printed as the December 1985 issue. Members of the SUBTAG operating board for 1985-86 are:

Army:	LTC Gerald P. Krueger, WRAIR - SUBTAG Chairman
	Dr. Jan Brecht, ARI
Navy:	Dr. Carl E. Englund, US NHRC
	LT Dennis Reeves, NAMRI
Air Force:	Dr. William F. Storm, USAF SAM
	Michael Frazier, USAF OTEC
Ex-Officio:	Dr. Robert G. Angus, DCIEM
	Dr. David F. Dinges, Ins of PA Hosp.

3. MAJ Roger Stallard of the Army's Soldier Support Center directed the panel of presentations and discussion on "Modeling Soldier Performance during Sustained Operations." Speakers were: Roger Stallard, Mr. Walt Morgan of Morgan Management Sys., and Dr. Terry Klopcic of the Army's Ballistics Res. Lab.

4. Dr. Don Headley of the Army Research Institute, who spoke on behalf of several different laboratories (including the Army Aeromedical Research Lab and the Institute of Environmental Medicine), and SFC James Clingan of the Army Human Engineering Lab gave a comprehensive update of sustained operations testing

program on the Army's P^2NBC^2 (Psychological & Physiological Effects of NBC on Armor Crews during Sustained Operations).

5. Dr. Sol Jacobson of Morgan Management Systems briefly described test efforts with the Walter Reed Army Institute of Research in evaluating the effects of sleep loss on performance of military policemen during continuous security missions at heavy weapons storage sites.

6. LT Dennis Reeves of the Navy Medical Res. Ins. described his lab's work with Navy SEALS in their rite-of-passage "hell-week" and some work with the Marines in cold weather operations off the Northern coasts of Europe.

7. Mike Frazier described potential applications of sustained operations research work to Air Force Operational Test and Evaluation of many developing Air Force systems.

8. Copies of most of the speakers' presentation materials are inclosures 4-9. Presentations by SFC Clingan and Dr. Jacobson were preliminary reports. Materials from their talks will be available only after final reports are complete.

9. LTC Krueger led the group in discussion of 3 issues:

1)Formation of a committee to prepare tri-service summary papers of major sustained operations issues for the 1990s and beyond, and to delineate military and research needs. Some of the material to be prepared should be in the form of an update of the Woodward & Nelson "User Oriented Review..." done for TTCP in 1974. The nucleus of the committee revolves around SUBTAG opearating board members. The committee hopes to have some draft papers ready for review by mid-1986.

2)Identification of research needs; funding programs to support work in the area, and determination of how to tie them together. Also, determination of appropriate roles for non-DOD researchers, defense contractors etc. In the Army we identified the on-going program at WRAIR and the P^2NBC^2 program. In the Navy, the program on sleep loss etc. at the Navy Health Research Center. In the Air Force, the occasional work at the School of Aerospace Medicne. If there are other specifically funded programs for research on sustained operations in any of the services, they are not so clearly known in the SUBTAG.

3)Future meeting plans: The 3rd meeting of the SUSOPS SUBTAG will be held in conjunction with the DOD HFE TAG at the Kennedy Space Center, Florida in mid-May 1986.

The 4th meeting is planned as an all-day workshop in Washington DC, about 21 or 22 August 1986, followed by a 2-hour American Psychological Association (APA) symposium on sustained operations and/or sleep deprivation to be held during the 87th annual APA convention in Washington DC 22-26 August 1986.

A call for abstracts of papers to be presented will be issued in December. The deadline for submission of abstracts for the APA symposium on sustained operations and/or sleep deprivation is 13 Jan 86; and 30 May 86 for presentation at the August SUS OPS workshop. As has been our custom, we hope to publish as many of the papers as we can in the open scientific literature, and as a minimum at least in a set of proceedings for the meetings. Thus, if you intend to present a paper, you should plan accordingly.

10. At the 15th meeting of the DOD HFE TAG, held 5-7 Nov 85 in San Diego, the Chairman distributed copies of the 22 Oct 85 Office of the Undersecretary of Defense for Research and Engineering (OUSDRE) Memorandum for Assistant Secretaries of Research commending the TAG for our tri-service coordination of research and exchange of technical data (Incl 3). Some of you may want to pass a copy of this correspondence on to members of your chain of command as helpful feedback recognizing the merits of our work at the highest of DOD levels.

11. LTC Krueger gave an oral report on the 2nd meeting of the SUS OPS SUBTAG to the DOD HFE TAG membership on 7 Nov 85. Several members of our SUBTAG, including Air Force rep Bill Storm and Navy Rep Carl Englund were in attendance.

Gerald P. Krueger

9 Incl as

GERALD P. KRUEGER, Ph.D.
LTC, US Army
Chairman, SUB TAG on
Sustained/Continuous Ops

Agenda for 2nd Meeting of the DOD HFE SUB TAG
on Sustained/Continuous Operations
3 October 1985, Baltimore, Maryland

0830	Introductions & SUB TAG Background	LTC Jerry Krueger Walter Reed
0845	Modeling Soldier Performance During Sustained Operations for: Training, Combat Developers, & Human Engineers Discussants: Mr. Walt Morgan of Morgan Mgmt Sys. Terry Klopcic, Army Ballistics Lab	MAJ Roger Stallard Soldier Support Ctr
0945	Coffee Break	
1000	Sustained Operations in a Chemical Battlefield Protective Posture: The Army's P^2NBC^2 Field Test Experiences	Dr. Don Headley USA Res Inst.
1030	IRONMAN - MOPP IV Endurance in Tanks	SFC James Clingan USA Human Eng Lab
1045	Sustained Operations During Security of Special Munitions	Dr. Sol Jacobson Morgan Mgmt Sys
1100	Marine SUS OPS in Cold Weather	LT Dennis Reeves Nav Med Res Ins
1115	SUS OPS & Air Force Operational Testing	Michael Frazier USAF T&E Ctr
1130	Planning Committee Business:	LTC Krueger

a) Committee to prepare DOD Summary Papers of major issues for the 1990's & beyond: military needs; research issues/needs.

b) Identification of Research Needs/Funding, Plans to tie the two together - the roles of non-DOD researchers, contractors etc.

c) Future - meetings, publication outlets etc.

1230 Meeting Adjourns

1235 Operating Board & Others Go to Working Lunch Together

Incl 1

Attendance Roster 3 Oct 1985
SUSTAINED/CONTINUOUS OPERATIONS SUB TAG

Name	Organization
Gerald P. Krueger	Walter Reed Army Ins. of Research
Daniel P. Redmond	" " " " "
Stephen C. Vance	" " " " "
Maria L. Thomas	" " " " "
William Kokinakis	US Army Ballistics Res. Lab
J. Terrance Klopcic	" " " "
Roger Stallard	US Army Soldier Support Center
Samuel K. Rock	" " " "
Karl J. Gunzelmon	US Dept of Army, ODCSRDA
Gary M. Bratt	HQ, USA Medical R&D Command
David G. Graham	USA Armor & Engineer Board
Donald Haggard	US Army Research Institute, Ft. Knox
Donald Headley	US Army Research Institute, Alex VA
Matilda Reeder	US Army Research Institute, Ft. Rucker
Barbara L. Bell	US Army Natick R&D Center
Jarod B. Jobe	HQ, USA TRADOC
C. Thomas Bennett	USA Combat Developments Exp Ctr.
James Clingan	USA Human Engineering Lab
Dennis L. Reeves	Naval Medical Research Institute
Thomas H. Brace	Naval Air Test Center
Sam Schiflett	USAF School of Aerospace Medicine
Michael Frazier	USAF Oper T&E Center
David L. Porterfield	HQ, USAF ISC/SEL, Norton AFB
Peter Angiola	OSD/DMMSO
Robert G. Angus	Canadian Defence & Civilian Institute of Environmental Medicine (DCIEM)

Incl 2

Attendance Roster for SUS OPS SUBTAG 3 Oct 85 Cont'd

Jackson Royal	Dept of Transportation
John A. Stern	Washington Univ Behav Res Lab
Charles Graham	Midwest Res Institute
Walter E. Morgan	Morgan Mgmt Sys
Solomon Jacobson	" " "
Elizabeth A. Woodward	Old Dominion University
David F. Dinges	Inst PA Hospital & Univ of Penn.
Mark Czarnolewski	Not affiliated

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

RESEARCH AND
ENGINEERING
(R&AT)

22 OCT 1985

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY
(RESEARCH, DEVELOPMENT AND ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, ENGINEERING AND SYSTEMS)
ASSISTANT SECRETARY OF THE AIR FORCE
(RESEARCH, DEVELOPMENT AND LOGISTICS)

SUBJECT: Department of Defense Human Factors Engineering Technical Advisory Group (DoD HFE TAG)

I am pleased at the response of the Services to the DoD and Congressional guidance on implementing the DoD HFE TAG. The HFE TAG was implemented by a Memorandum of Understanding signed by the Assistant Secretaries of the Services in November 1976. The TAG, in its nearly nine years of existence, has been a productive vehicle for exchanging technical data and coordinating research of the DoD laboratories, the National Aeronautics and Space Administration, and the Federal Aviation Administration. Examples of concrete results attained by the HFE TAG include:

o Inter-Service coordination in the following HFE technical areas:

- Controls and Displays
- Aviation Personnel Screening and Prediction
- Logistics
- Test and Evaluation
- Manned System Modeling
- Standardization
- Workload
- User-Computer Interaction
- Voice Interactive Systems
- Technical Society/Industry Liaison
- Sustained/Continuous Operations

o The development of an HFE practitioner training course implemented by all military Services.

o The cooperative compilation and dissemination of research pertinent to the hardware and system design process.

o The regular review and update of military specifications, standards and design documents by the services and industry.

I encourage the Services to continue their vigorous support of the HFE TAG and other similar inter-Service research coordinating groups.

Please convey our gratitude through the present Service coordinators for the HFE TAG.

Army: Dr. Michael Strub, Army Research Institute for the Behavioral and Social Sciences

Mr. Clarence Fry, U.S. Army Human Engineering Laboratory

Navy: Dr. John O'Hare, Office of Naval Research
LCDR Thomas M. Mitchell, Pacific Missile Test Center

Air Force: Mr. Cy Crites, Present Chairman, Edwards Flight Test Center

Dr. Richard Schiffler, Aeronautical Systems Division

Donald I. Carter
Acting Deputy Under Secretary
(Research and Advanced Technology)

Editor's note: Due to the lengthiness of the briefings, enclosures 4-9 are not included in these TAG Minutes. Copies of the visual materials of the following presentations may be obtained from LTC Krueger or the TAG Coordinator:

Soldier Performance in Combat Models -- R. Stallard

Modeling Soldier Performance in Sustained Operations -- W. E. Morgan

AURA: Army Unit Resiliency Analysis Methodology -- J. T. Klopcic

Psychological and Physiological Effects of NBC & Extended Operations on Combined Arms Crews -- D. B. Headley

Navy Medical Research Institute -- D. Reeves

Approach to the OT&E of Air Force Systems Under Sustained/ Continuous Operations -- M. L. Frazier

ATTACHMENT K.1

TRI-SERVICE HUMAN FACTORS STANDARDIZATION

STEERING COMMITTEE -- VIEW GRAPHS

HFSSC MEETINGS

NR	DATE	LOCATION	MEM	ILR	OTH	TOT
1	13 DEC 78	HQ, NAVMAT, WASHINGTON, DC	4	1	3	8
2	5 JUN 79	MICOM, REDSTONE ARSENAL, AL	4	2	2	8
3	5 DEC 79	NASA-AMES, SUNNYVALE, CA	4	3	4	11
4	17 NOV 80	NEW ORLEANS, LA	3	3	10	16
5	18 MAY 81	NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA	3	3	6	12
6	12 JAN 82	ORLANDO, FL	5	4	10	19
7	27 JUL 82	AIR FORCE ACADEMY, CO	6	3	8	17
8	8 MAR 83	EL PASO, TX	5	5	8	18
9	4 OCT 83	FAA TECH CTR, ATLANTIC CITY NJ	8	3	9	20
10	15 MAY 84	OXNARD, CA	8	3	12	23
11	6 NOV 84	WEST POINT, NY	7	3	4	14
12	7 MAY 85	SAN ANTONIO, TX	5	2	13	20
13	5 NOV 85	SAN DIEGO, CA	6	3	8	17

HFSSC AS OF 5 NOV 85

MEMBERS

CHAIRMAN	MR. GERALD CHAIKIN (HEL-MICOM)
ARMY (HE&LS)	MR. CLARENCE A. FRY (HEL)
ARMY (P&T)	MR. JOHN L. MILES, JR. (ARI)
NAVY MEMBER (HE&LS)	MR. HOWARD ARNOFF (NAVAIR)
NAVY MEMBER (P&T)	CDR LARRY M. DEAN (CNO)
AIR FORCE (HE&LS)	MR. STEVE A. HECKART (AFAMRL)
AIR FORCE (P&T)	MR. ROBERT N. DEEM (AFHRL)
EX-OFFICIO	MR. STEVE MERRIMAN (DTDAC)
	MR. LARRY PETERSON (HEL)
	LTC. GERALD KRUEGER (WRAIR)
	CAPT ROBERT L. DOTSON (BMO)

INDUSTRY LIAISON REPRESENTATIVES

AIA:	MR. MAURICE A. LARUE, JR.
EIA & NSIA:	MR. WOLF J. HEBENSTREIT
HFS:	DR. JULIEN M. CHRISTENSEN
AIIE:	DR. MARK M. BRAUER

AGENDA

Thirteenth Meeting of the Tri-Service Human Factors Standardization Steering Committee

1.	Minutes of Previous Meeting	Chaikin
2.	Announcements	
	a. Correspondence Summary	Chaikin
	b. Membership Changes	"
	c. NASA Man-Systems Integration Standards	"
	d. Other	
3.	Status Reports	
	a. Status of Projects	Chaikin
	b. HFAC-0009	Miles/Merriman
	c. HFAC-0016	
	d. HFAC-0019	Peterson
	e. HFAC-0020	"
	f. HFAC-0024	Chaikin
	g. HFAC-0027	
	h. HFAC-0028	
	i. HFAC-0029	"
	j. HFAC-A014	"
	k. HFAC-F002	Herbert
	l. HFAC-F003	Schiffler
	m. HFAC-N003	Chaikin
	n. HFAC-N004	"
	o. MIL-PRIME Update (if applicable)	Schiffler
	p. Task Analysis Update (if applicable)	Geddie
	l. ASSP Update (if applicable)	
4.	Unfinished Business	
	a. HFAC Program Plan, R4	Chaikin
	b. Life Support & Biomedical Factors Coverage	Krueger
	c. PMTC Review of 1472C, para 5.9	Mahar
	d. Fifth Percentile Female in the Workforce	Herbert
	e. TAG Proposals to the JTCG/HFE/HMI	Geddie
5.	New Business	
	a. HFAC Program Plan, R5	Chaikin
	b. Other	

STATUS OF PROJECTS

HFAC#		COMPLETED MILESTONE	DATE	STATUS
0009	PERS/TNG TASK DOCS & DIDS EPS	COMPLETED	OCT 85	FORMAL REV NOV 85
0016	MIL-STD-1294A	COMPLETED	AUG 85	COMPLETED
0019	NUMERIC KEYPAD STANDARDIZATION EPS	INITIATED	APR 83	COMPL BY 30 DEC 85
0020	ALPHANUMERIC KEYBOARD ARRANGEMENTS EPS	INITIATED	OCT 84	COORD BY 30 SEP 85
0024	DOD-HDBK-761	COMPLETED	JUN 85	COMPLETED
0027	HE PROCEDURES GUIDE (DOD-HDBK-XXX)	INITIATED	AUG 85	COMPL BY JUN 86
0028	SAE J925 (ADOPTION)	INITIATED	JUL 85	COMPL BY SEP 87
0029	SAE J88	INITITED	JUL 85	COMPL BY SEP 87
F002	HFE/MGT FOR ICBM SYS	COORDINATION	JUL 84	
--	ADOPTION, ANSI S1.8			(INIT BY DEC 85)
--	ADOPTION, ANSI S1.10			(INIT BY DEC 85)
N003	MIL-STD-740-1	INITIATED	APR 85	COMPL BY JUN 86
N004	MIL-STD-740-2	INITIATED	APR 85	COMPL BY JUN 86
A014	MIL-HDBK-759A, N1	COORD	JUN 85	COMPL BY DEC 85

Manpower, Personnel and Training (MPT)

Data Requirements Study

FINAL REPORT

OCTOBER 1985

Engineering Practice Study

DoD Standardization Project No. HFAC-0009

MIL-STD-1294A
12 August 1985
Superseding
MIL-STD-1294
9 March 1981

MILITARY STANDARD

ACOUSTICAL NOISE LIMITS

IN HELICOPTERS



AMSC A3242

FSC HFAC

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

METRIC
DOD-HDBK-761
28 June 1985

MILITARY HANDBOOK

HUMAN ENGINEERING GUIDELINES FOR MANAGEMENT INFORMATION SYSTEMS

METRIC



NO DELIVERABLE DATA REQUIRED
BY THIS DOCUMENT

AREA HFAC

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

TABLE I. HUMAN FACTORS STANDARDIZATION DOCUMENTS *

DESIGNATION	DATE	TITLE
MIL-H-46855B	31 Jan 79	HE Req for Mil Sys, Equip and Facil
DI-H-7051	1 Jun 79	Human Engineering Program Plan
DI-H-7052	1 Jun 79	Human Engineering Dynamic Simulation Plan
DI-H-7053	1 Jun 79	Human Engineering Test Plan
DI-H-7054	1 Jun 79	Human Engineering System Analysis Report
DI-H-7055	1 Jun 79	Critical Task Analysis Report
DI-H-7056	1 Jun 79	Human Engineering Design Approach Document-Operator
DI-H-7057	1 Jun 79	Human Engineering Design Approach Document-Maintainer
DI-H-7058	1 Jun 79	Human Engineering Test Report
DI-H-7059	1 Jun 79	Human Engineering Progress Report
Amendment 1	5 Apr 82	
Amendment 2	5 Apr 84	
MIL-STD-740B	13 Jan 65	Airborne & Structureborne Noise Meas & Acc Crit of Shipboard Equip
MIL-STD-783D	18 Dec 84	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-1280	28 Jan 69	Keyboard Arrangements
MIL-STD-1294A	12 Aug 85	Accoustical Noise Limits in Helicopters
DI-H-7130		Noise Control Measures Report (Helicopters)
DI-H-7031		Noise Level Assessment Report (Helicopters)
MIL-STD-1295A	26 Jun 84	HFE Des Criteria for Heli Cockpit Display Symbology
MIL-STD-1472C	2 May 81	HE Des Criteria for Mil Sys, Equip and Fac
Notice 1	1 Sep 83	
Notice 2	10 May 84	
MIL-STD-1473A	10 Feb 76	Std Genl Reqts for Color and Marking of Army Materiel
Notice 1	29 Jul 83	
MIL-STD-1474B	18 Jun 79	Noise Limits for Army Materiel
DI-H-1336	29 Jul 80	Report of Noise Test
Notice 1	10 Oct 80	
Notice 2	20 Apr 84	
DOD-STD-1477	31 May 83	Symbols for Army Air Defense System Displays
Notice 1	31 May 83	
MIL-STD-1787	10 Dec 84	Aircraft Display Symbology
DOD-HDBK-743	3 Oct 80	Anthropometry of US Military Personnel
MIL-HDBK-759A	30 Jun 81	Human Factors Engineering Design for Army Materiel
DOD-HDBK-761	28 Jun 85	HE Guidelines for Mgt Info Sys
SAE HIR-1622	8 Mar 85	Noise Contl in Fluid Pwr Sys of Marine Veh
SAE J185-1970	30 Sep 81	Access Sys for Const & Indl Equip

*Excluding unique data items (UDIs) and data items approved for one year of use.

Department of Defense

HUMAN FACTORS STANDARDIZATION PROGRAM (HFAC) PLAN

REVISION 4

21 AUG 85

DISTRIBUTION STATEMENT A. APPROVED FOR PUBLIC RELEASE ; DISTRIBUTION IS UNLIMITED.

THE OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301-8000

ACQUISITION AND LOGISTICS

21 AUG 1985

The Human Factors (HFAC) Standardization Program is approved for implementation at all levels within the Department of Defense.

This program plan is the fourth revision to the Human Factors Standardization Document Program Plan published 19 June 1978. As Lead Service Activity, the U.S. Army Missile Command, Redstone Arsenal, Alabama, coordinated this Revision, as developed by the Human Engineering Laboratory Detachment - MICOM, with DoD components and Industry. This activity is responsible for implementation and continued management of the Human Factors Standardization Area.

It is the responsibility of each identified DoD activity to support the implementation of this Plan and provide the resources necessary to complete the identified tasks within the indicated milestones as provided for under the Defense Standardization and Specification Program (DSSP).

Approved by:

John A. Mittino
Deputy Assistant Secretary
(Production Support)

8/21/85
DATE

MSIS — Purpose

To develop a set of man-system integration standards, requirements, and guidelines for human presence in space. They will be based on existing standards, requirements, and guidelines as far as possible. Gaps and discrepancies in existing data will be identified and resolved with the help of government/industry experts.

MSIS — Statistics

Customer:	JSC with MSFC and Headquarters
Value:	~$972,500
Duration:	18 months, starting ~ July 1985
Subcontractors:	LMSC (39%), Essex (8%), GIAG experts (13%)

ATTACHMENT K.2

TRI-SERVICE HUMAN FACTORS STANDARDIZATION STEERING

COMMITTEE -- MINUTES OF 7 MAY 1985

Minutes of the Twelfth Meeting of the
Tri-Service Human Factors Standardization Steering Committee (HFSSC)

San Antonio, TX
7 May 1985

PURPOSE

The twelfth meeting of the HFSSC was convened 0830-1100 hours on 7 May 1985 in the Holly Room of the Holiday Inn Northwest Loop 410, San Antonio, TX, in conjunction with the fourteenth meeting of the DoD Human Factors Engineering (HFE) Technical Advisory Group (TAG). The purpose of the meeting was to address the agenda items of enclosure 1.

ATTENDANCE

Members and Alternates* Present:

Mr. Gerald Chaikin, HEL Detachment-MICOM
Mr. Clarence A. Fry, HEL
Mr. Larry A. Peterson, HEL
LTC Gerald P. Krueger, WRAIR
Mr. Richard J. Schiffler, ASD

Industry Liaison Representatives

Dr. Mark M. Brauer, AIIE
Mr. Wolf J. Hebenstreit, NSIA/EI

Others Present:

Mr. Peter Angiola, DMSSO
Mrs. Helen C. Boggs, MICOM
Dr. James C. Geddie, HEL
Mr. Dale A. Mahar, PMTC
LCDR Tom Mitchell, PMTC
Dr. Gene Schneider, NWC
LT Ed Trautman, NPRDC
CPT Mike Moroze, AFSC
Mr. Monty Joel, ESD
Mr. Doug Miller, HQ/SD (AFSC)
Mr. Nat Davis, AFLC
Ms. Barbara Woolford, JSC (NASA)
Mr. Ross L. Morgan, UES

Members Absent:

Dr. John L. Miles, Jr., ARI
Mr. Tom Metzler, AVSCOM
Dr. Heber G. Moore, NAVMAT
CDR Larry Dean, NPRDC
Mr. Stephen C. Merriman, NADC
Mr. Robert N. Deem, AFHRL
Mr. William C. Herbert, BMO

Industry Liaison Representatives Absent:

Mr. Maurice A. Larue, Jr., AIA
Dr. Julien M. Christensen, HFS

DISCUSSION

1. MINUTES OF PREVIOUS MEETING

Mr. Chaikin stated that the third sentence under paragraph 3.1 of the draft minutes had been changed, in response to a request by the AIIE representative, Dr. Brauer, to read "Conflict with the U/CI STAG was also noted as was absence of the AIIE Liaison Representative, Dr. Brauer, who was attending the U/CI STAG meeting." Mr. Chaikin noted that since no other changes had been requested as result of mailing of the draft, it had been approved 21 March 1985.

2. ANNOUNCEMENTS

a. Correspondence Summary.- A summary of incoming and outgoing correspondence (encl 2) was furnished the attendees. No request for copies of non-distributed correspondence was made.

b. Membership and STAG Schedule Block.- Mr. Chaikin provided copies of the current membership listing (encl 3) and noted that the Navy member (P&T) should read "CDR Larry M. Dean (NPRDC)". He also advised that the HFSSC would meet during block "A" sessions of each TAG meeting. He noted that the only current conflicts seemed to be with the Workload STAG, currently chaired by Mr. Metzler and the HEGED Committee on which Mr. Chaikin is an Army representative. The Sustained/Continuous Operations and U/CI STAGS, currently chaired by MAJ Krueger and Mr. Peterson, respectively, have been allocated time in the block "B" sessions. Copies of the HFSSC meeting attendance record was furnished (encl 4).

c. Other.- Mr. Chaikin noted that the current HFS directory and officer listing cites the HFSSC as an organization receiving appointed HFS representation (encl 5). Mr. Chaikin introduced Mr. Peter Angiola and Ms. Helen Boggs, representing the Defense Materiel Specifications and Standards Office (DMSSO) and the HFAC Lead Service Activity (MICOM), respectively.

3. STATUS REPORTS

a. Status of Projects.- Mr. Chaikin furnished the attendees with summaries of scheduled actions, dates and status for current HFAC projects (encl 6).

b. HFAC-0009.- In the absence of Mr. Merriman and Dr. Miles, Mr. Chaikin reported that he understood the only action remaining is to put together the EPS report for scheduled June coordination. He noted that the EPS recommendations have already been included in the draft HFAC Program Plan, R4.

c. HFAC-0016. - In the absence of Mr. Metzler, Mr. Chaikin reported that the completion date for this project (Revision of MIL-STD-1294, Acoustical Noise Limits in Helicopters) had been extended to the fourth quarter of FY85.

d. HFAC-0019. - Mr. Peterson reported that the expected completion date for this project (Engineering Practice Study of Keypad Arrangements) is fourth quarter of FY85 and that formal coordination of the EPS report is expected next month.

e. HFAC-0020.- Mr. Peterson reported that expected completion date for this project (Engineering Practice Study of Keyboard Arrangements) is first quarter of FY86.

f. HFAC-0024.- Mr. Chaikin stated that the line originals of "Human Engineering Guidelines for Management Information Systems," now designated as DOD-HDBK-761, are currently being prepared for approval and submission to the Navy Publications and Forms Center. Mr. Peterson stated that the U/CI STAG will review the handbook after it is published and plans to organize a subgroup to define technical content of a revision. At that point, Dr. Brauer brought up the subject of section 5.15 of MIL-STD-1472 and its relationship to DOD-HDBK-761. Mr. Fry noted the intents of a standard vs a handbook and discussed relationship in terms of binding provisions and background, guidance and data. Mr. Peterson advised that the U/CI STAG also plans to develop the material in 5.15 of MIL-STD-1472 as a stand-alone document. Mr. Chaikin concluded the discussion by advising Mr. Peterson that the HFSSC would look to the U/CI STAG to serve as agent for revision of DOD-HDKB 761 as soon as possible after publication of the initial issue and to serve as agent for converting 5.15 of MIL-STD-1472C to a stand-alone standard at such time as the U/CI STAG considers appropriate.

g. HFAC-0025.- Mr. Chaikin reported that this project, completed 18 Dec 84, merely transferred MIL-STD-783D (Legends for Use in Aircrew Stations and on Airborne Equipment) to the HFAC Standardization Area.

h. HFAC-0026.- Mr. Chaikin reported that this completed project resulted in an acceptance notice, issued 8 March 1985, on SAE HIR 1622, Noise Control in Fluid Power Systems of Marine Vehicles, and that the military coordinating activity was NAVSEA.

i. HFAC-0027.- Mr. Chaikin announced that an RFP for a Human Engineering Procedures Guide was recently released.

j. HFAC-A014.- Mr. Chaikin reported that this project to update the Carbon Monoxide exposure and selected other provisions of MIL-HDBK-759A via a change notice would begin presently.

k. HFAC-F002.- Mr. Chaikin stated, in view of comments on proposed MIL-STD-XXXX, Human Factors Engineering and Management of ICBM Systems, at the last HFSSC meeting, that he had written to the Lead Service Activity recommending that any requested MIL-STD number not be assigned and advising that the twelfth meeting of the HFSSC would consider cancellation of the project or some other proposal for handling the material that appears in the draft standard. Since Mr. Herbert could not attend the meeting, Mr. Chaikin requested that the issue be deferred to the next meeting. The members and industry liaison representatives concurred.

l. HFAC-F003.- Dr. Schiffler stated that the Army reportedly signed off on using MIL-STD-1787 vice MIL-STD-884, thereby making it a coordinated MIL-PRIME. Mr. Chaikin stated he was not aware of such concurrence, assumed that if such

concurrence was given that it came from AVSCOM in view of airborne application, but could not check this assumption with Mr. Metzler who was unable to attend. (The information was provided to Mr. Metzler at the conclusion of the meeting.)

m. HFAC-N003.- Mr. Chaikin reported that this project was a new start on what was previously HFAC-N001.

n. HFAC-N004.- Mr. Chaikin reported that this project was a new start on what was previously HFAC-N002.

o. MIL-PRIME-Update.- Dr. Schiffler described an ambitious schedule of briefings on the MIL-PRIME program to military and industry audiences by ASD's Support System Engineering technical director. He also announced the recent publication of MIL-STD-1787 and prospective publication in June and July of MIL-PRIMEs on Aircraft Lighting and Aircraft Audio Systems, respectively. Dr. Schiffler described the work on the human engineering and U/CI MIL-PRIMES. Mr. Fry asked if ASD was trying to sell the MIL-PRIME program to other organizations and services and Dr. Schiffler responded that they were. Mr. Davis asked if the briefing could be given to the HFSSC. Dr. Schiffler stated that he'd check to see if an 1/2-hour briefing could be arranged. Mr. Fry expressed concern about the MIL-PRIME philosophy. Mr. Chaikin asked if it would be useful to set aside 20-30 minutes after the briefing to discuss these concerns, rather than covering them at this time, and Mr. Fry and others agreed. At the close of the meeting, Dr. Schiffler provided a hard copy set of MIL-PRIME briefing viewgraphs (encl 7).

p. Task Analysis Update.- Dr. Geddie reported on the "offline" effort by HEL and the HFTE STAG to structure material suitable for use as a possible MIL-STD on Task Analysis. HEL, he noted, has contracted this work to Battelle Columbus Lab and is keeping it oriented toward Army T&E for the time being. He advised that the T&E STAG's consensus is that the effort is on track and announced that the first draft should be available at the next HFTE STAG meeting. Dr. Geddie understands that, at the appropriate time, the HFTE STAG will decide if the draft is suitable for establishing a formal standardization project. The document is seen as containing four sections: 1. Requirements, 2. Tailoring Guide, 3. DIDs and 4. Methodology Guidance. He remarked that structuring of task analysis DIDs would seem to involve some change to DI-H-7055, 7056 and 7057. He will continue to keep the HFSSC apprised of status and decisions.

q. ASSP update.- Dr. Schiffler reported that the Aircrew Stations Standardization Panel (ASSP) met 27-28 March; identified MIL-STD-203 (Aircrew Station Controls and Displays for Fixed Wing Aircraft), MIL-STD-250 (Aircrew Station Controls for Rotary Wing Aircraft), MIL-STD-411 (Aircrew Station Signals) and MIL-STD-850 (Aircrew Station Vision Requirements for Military Aircraft) as requiring updates; noted that a MIL-STD-411 working group has been organized; and that a draft revision of MIL-STD-203 is about ready for circulation. Dr. Schiffler also advised that he chairs a Night Vision/Aviation Lighting System Committee which is developing a Tri-service document to be published as a military specification with Navy lead.

5. NEW BUSINESS

a. TAG Proposals to the JTCG/HFE/HMI.- Mr. Chaikin noted that his solicitation for inputs to the Joint Technical Coordinating Group for Human Factors Engineering/Human Machine Interface, as requested by the TAG representative to the JTCG/HFE/HMI (Dr. Geddie), inadvertently imposed a 29 March instead of a 29 April suspense, probably accounting for lack of response in time for this meeting. Dr. Geddie reminded the committee that submission through the TAG of candidate study, research or other efforts appropriate for sponsorship by the JTCG/HFE/HMI is a continuing need. As such, it was agreed to keep the item on the agenda.

b. Other.- A highlight of the meeting was representation from both DMSSO and the HFAC Standardization Project Officer from the Lead Service Activity--Mr. Angiola and Ms. Boggs, respectively. Mr. Angiola provided a copy (encl 9) of the current (Jan 85) Defense Standardization and Specification Program Report to Congress along with suggestions regarding the thrust of the HFAC standardization accomplishment reports. Of 32 standardization areas only about a half-dozen were covered by the Technology Standardization Section and HFAC was one of the areas covered. Finally, Dr. Schneider announced that NWC has recently developed a guideline for acquiring desktop computers on the basis of human engineering and other user-critical features and announced that copies of the guidelines are available on request.

9 Encls

GERALD CHAIKIN
Chairman

4. UNFINISHED BUSINESS

a. MIL-STD-490 Coverage of GAO Target Areas.- Mr. Chaikin noted, from the last minutes, that Mr. Heckart had contacted the preparing activity of MIL-STD-490 to determine status of the HFSSC-proposed changes and reported that the HFSSC recommendations are being kept on file pending proposed revision of or change notice action on the standard. After a brief discussion--primarily between Mr. Fry, Dr. Brauer and Mr. Hebenstreit--regarding the merits of retaining this item on the agenda, a vote was taken as a basis for dropping the item (Drop: Mr. Hebenstreit, Mr. Fry, Dr. Schiffler, Mr. Chaikin. Retain: Dr. Brauer, LTC Krueger, Mr. Peterson.)

b. HFAC Program Plan, R4.- Mr. Chaikin announced that the draft was sent out for formal coordination, 1 May 85 with a 10 July suspense and provided information copies (encl 8) to the attendees. Dr. Brauer requested that two additional copies be sent to him and asked that the next formal coordination letter going to AIIE identify him as POC to facilitate internal coordination. Dr. Schiffler also requested an extra copy. Mr. Chaikin agreed to take care of these items.

c. User/Computer Interface.- Mr. Peterson advised the Committee that the U/CI STAG is willing to generate the stand-alone U/CI standard and the revision of DOD-HDBK-761 as previously mentioned. Consequently, this item was dropped from the agenda as unfinished business but will be covered, in the future, by status reports upon establishment of formal projects.

d. Life Support & Biomedical Factors Coverage.- MAJ Krueger stated that he would a) write a letter to the Occupational and Environmental Health Lab at the School of Aerospace Medicine requesting comments on the BMO draft document and b) send the Tri-service Technical Group for MIL-STD-1472 a copy of the BMO draft, redlined to highlight provisions which can be considered for inclusion in MIL-STD-1472.

e. PMTC Review of MIL-STD-1472C, Para 5.9.- Mr. Mahar announced that the results of the Pacific Missile Test Center review of the Maintainability Design section of MIL-STD-1472 will be sent out in proposed revision form for review in the near future. He advised the committee that a dozen copies would be sent to the Tri-service Technical Group for MIL-STD-1472.

f. Fifth Percentile Female in the Workforce.- This subject was briefly discussed--primarily by Mr. Hebenstreit, Dr. Brauer, Mr. Fry and Dr. Schiffler. Mr. Hebenstreit noted that the most prominent problems seemed to be in the fighter cockpit design. Dr. Brauer agreed and felt that the problem was common to aircrew stations. Mr. Chaikin asked, in view of the aircrew station focus, if the ASSP had ever reviewed the problem. Dr. Schiffler responded that it had but never resolved it. The discussants agreed that the issue involves a policy statement that cannot be resolved by the HFSSC. Mr. Chaikin suggested, without dissent, that this item be deferred to the next meeting since Mr. Herbert was unable to attend the twelfth HFSSC meeting.

ATTACHMENT L

TRI-SERVICE WORKLOAD COORDINATING COMITTEE

-- MINUTES, VIEW GRAPHS

DRAFT MINUTES: Sub Technical Advisory Group (SubTAG)

Workload Coordinating Committee

1. The meeting of the SubTAG Workload Coordinating committee was held on 5 November 1985 in conjunction with the Department of Defense Human Factors Engineering Technical Advisory Group meeting at the Kona Kai Resort, Shelter Island, San Diego, California. The session was chaired by Heidi Fiedler from the Naval Underwater Systems Center. Persons who attended the session are listed on the attached roster of attendees (Enclosure 1), along with their Tri-Service, NASA, or other affiliation.

2. The meeting was divided into three phases; (a) Announcements and New Business, (b) Action Items, and (c) Presentations.

(a) The chairmanship was rotated from Tom Metzler of the Army Aviation Systems Research Command, to Heidi Fiedler of the Naval Underwater Systems Center, Newport, Rhode Island. Three items of new business were discussed:

1. The first was the possibility of an extended workload Subtag meeting in the spring of 1986. It was proposed that this 2 to 3 day meeting would be conducted like a workshop rather than the standard format for serial presentations. Through a vote it was indicated that approximately 20 people would be interested in attending such a session. It was suggested that this meeting be split up between Monday and Friday around the mother TAG meeting to avoid the problem of two travel requests being submitted in close time proximity. Another alternative would be to hold the workshop in conjunction with a national meeting, i.e., NAECON, HFS. The group was surveyed as to what would be most beneficial as far as content in such a meeting. The results were:

- o Tutorials, not just paper presentations.
- o Discussions on how to take HF principles out of the lab and into the field.
- o Available measurement techniques and how to use them.
- o How to validate a system.
- o Nonintrusive measures using the 1553 Bus.
- o How to validate measures.
- o Methodologies and relations to other performance measures.
- o Workload and Training.
- o How do designers (development w/o research) address these issues, i.e., allocation of functions.

2. The issue of a chair select for the SubTAG was addressed. The objective is to provide support and backup to the current chairman and continuity upon rotation of the chair position. This position should rotate to the Air Force next, and anyone currently assuming this position would move into the chairmanship in November 1986. Interested members were asked to report to the current chairperson, H. Fiedler.

3. It was suggested that the workload SubTAG develop liaisons with all the other SubTAGS. Many of the other SubTAGs (i.e., Controls and Displays, Modeling, and UCI) are dealing with problems and issues that are very closely related to human workload. A liaison system would allow for greater communication between these SubTAGs than is possible though the final day summary presentations. This issue will be pursued further by the chairman of the workload SubTAG, H. Fiedler.

(b) A draft of the Workload Standards Document was distributed by G. Reid from Wright-Patterson Air Force Base. This document is evolving as a workload subtag product and consequently should be thoroughly reviewed by the members of this group. It is desired to have feedback from the members of the SubTAG concerning the basic approach, the need for the document, or any other relevant comments. Members are encouraged to send their replys to H. Fiedler as soon as possible. An extensive review of this document will be planned for the spring meeting.

The workload register is completed and is currently being published.

(c) Presentations:

PHYSIOLOGICAL AND BEHAVIORAL WORKLOAD MEASURES IN FULL-MISSION SIMULATORS

Dr. Richard Schiffler
ASD/ENECH
Wright-Patterson Air Force Base

Dr. Schiffler was presenting for J. Gavern who is currently involved in this work.

The main efforts of the Human Factors branch at the Aeronautical Systems Division are in the applications area not in the research area. The goal is not to develop metrics but to apply them in support of various weapon systems. The main objective is to use workload metrics in designing and developing crew stations. The Human Factors branch has a Crew Station Design Facility (CSDF) where engineering man-in-the-loop simulations address specific issues (e.g., Displays and Controls used on the F-16).

Dr. Schiffler described workload as a "means to an end". The end being how to design a cockpit to effectively use the man in the system. The CSDF currently has three simulators, an F-16, an A-10 and a C-18 widebody simulator. These simulators are used as engineering design tools and not as training simulators. Head-ups display capabilities are also available. The CSDF is currently running a series of simulations in support of several program offices.

Some of the topics addressed in the past and currently of concern are: crew composition level related to reducing the number of crew members, night visual simulations, human-machine function allocation, and the location and arrangement of controls. The branch is currently very heavily committed to supporting the F-16 project office. Such issues as information flow and formatting, multifunction displays, and automation are currently being studied. The questions to be assessed are: Does it reduce the workload level? Does it modify the workload level? What is necessary is a tactical evaluation of both systems and subsystems to thoroughly understand the total human-machine integration issue.

The CSDF uses operational crews of different levels in their experiments. Some of the performance measures used are: aircraft parameters, subjective questionnaires, video taping, target acquisition data, and time. Dr. Schiffler than reviewed the workload assessment methods used by his branch.

The workload assessment methodologies used include: task analysis, direct observation (through participation with C-141 and C-135 aircraft flight tests), aircraft parameters, performance data, subjective questionnaires, (e.g., MCH, SWAT). Traditionally the subjective methods have provided most of the data and the Human Factors branch would like to use more behavioral and physiological techniques as they appear to have promise.

One task analytic behavioral method used by the branch is the Task Analytic approach. In this approach a Datamyte is used to record the time available to accomplish a task versus the time required. The key here is to identify each major task a pilot is performing and record the time spent on the task. This method has been used in some of the CSDF simulations and test programs.

The task analytic performance approach looks at very specific things such as target acquisition and navigation and flight control. Reaction time measures and perceptual motor assessments comprise this approach. The physiological approach is in its nascent stages and these techniques are just moving into applied settings. Some of the data obtained, in addition to performance data, are pupil dilation, brain activity, voice analysis, muscle tension, and galvanic skin response.

To explore further and to apply physiological and behavioral workload techniques in our engineering simulations the Human Factors Branch has signed a contract with Ergotech to develop the behavioral and physiological workload methodologies, including hardware and software, to use in simulations.

This project is oriented toward developing nonobtrusive techniques to use workload metrics, in addition to other performance metrics, to assess various crew station configurations. The initial phase includes the determination of touch capabilities, development of hardware, demonstration and testing, design and fabrication, and instalation in the CSDF.

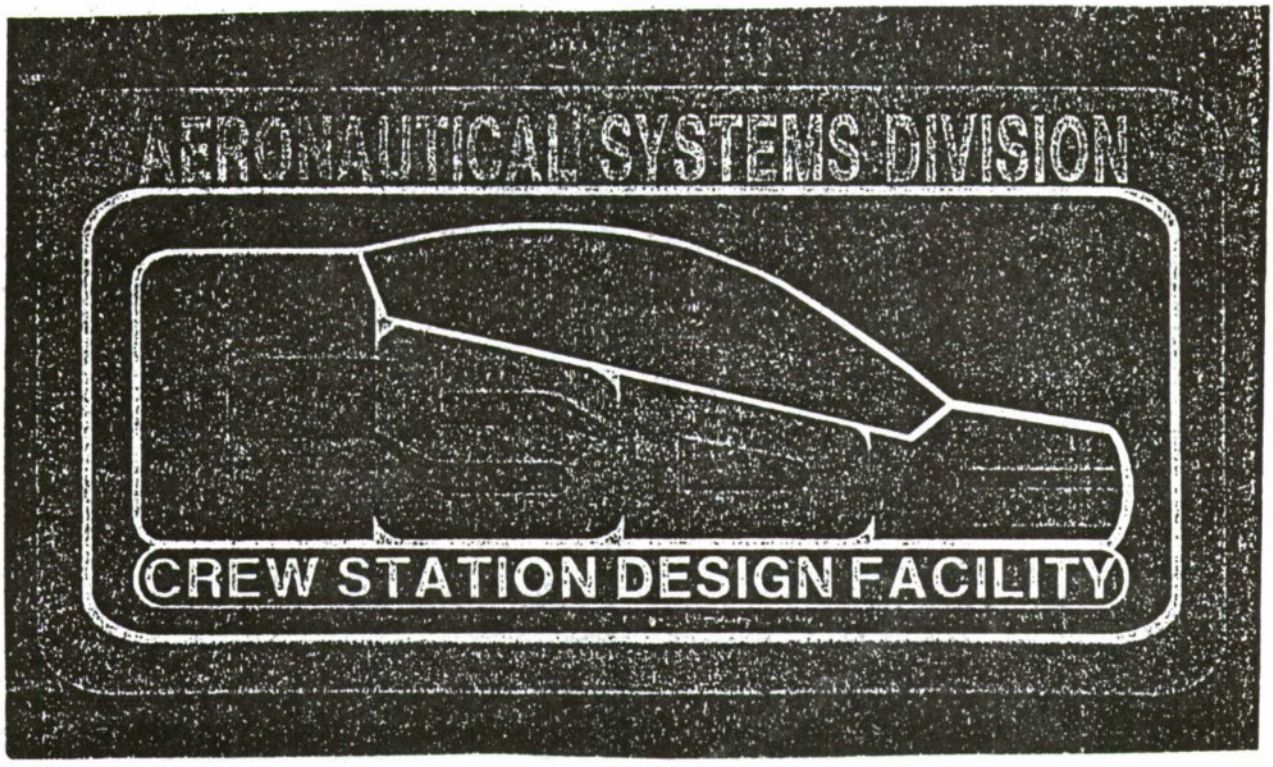
The objective is to develop techniques that can be used in all three simulators. It is necessary to have the flexibility to modify the various physiological and performance techniques for a particular activity of interest (e.g., motor responses).

A problem that has existed in the workload arena for years is the development of global rather than specific measures of crew or pilot workload. It is hoped that this project will provide more specific measures of the different aspects or dimensions of workload. Workload is not a one-dimensional measure but consists of various components that will determine what the workload level is and how it varies.

By looking at the physiological and performance measures Dr. Sniffler hopes that researchers will have a better handle on not only the overall workload level, but the potential for a given design to increase workload under certain environmental conditions. The main purpose is to use these techniques as diagnostic tools to provide information about the "best designs". For example, if you have several configurations that look similar and in the first cut the relative workloads or processing times are the same, hopefully workload measures will be a good diagnostic tool to say "under these conditions, this configuration is in fact a better design."

Dr. Sniffler's CSDF efforts are in the early stages of trying to apply these behavioral and physiological techniques. The quest is for a

quick, easily adaptable tool that is nonintrusive, has a stand-alone capability, and that can easily be calibrated to the system. Intrusiveness is a big problem with workload assessment methods. Hopefully the result of this project will be a nonintrusive technique to look at and assess design layouts of particular cockpits. It is necessary to take techniques out of lab into the development community to see how they can best aid us in the major task of cockpit design.



PERFORMANCE MEASURES

- MISSION LOG SHEETS
- AIRCRAFT PARAMETERS
- SUBJECTIVE QUESTIONNAIRES
- VIDEOTAPE
- TARGET ACQUISITION
- TIME

HUMAN ENGINEERING DESIGN TOOL

HUMAN VS MACHINE FUNCTION ALLOCATION

LOCATION & ARRANGEMENT OF CONTROLS & DISPLAYS

CREW TASK LOADING

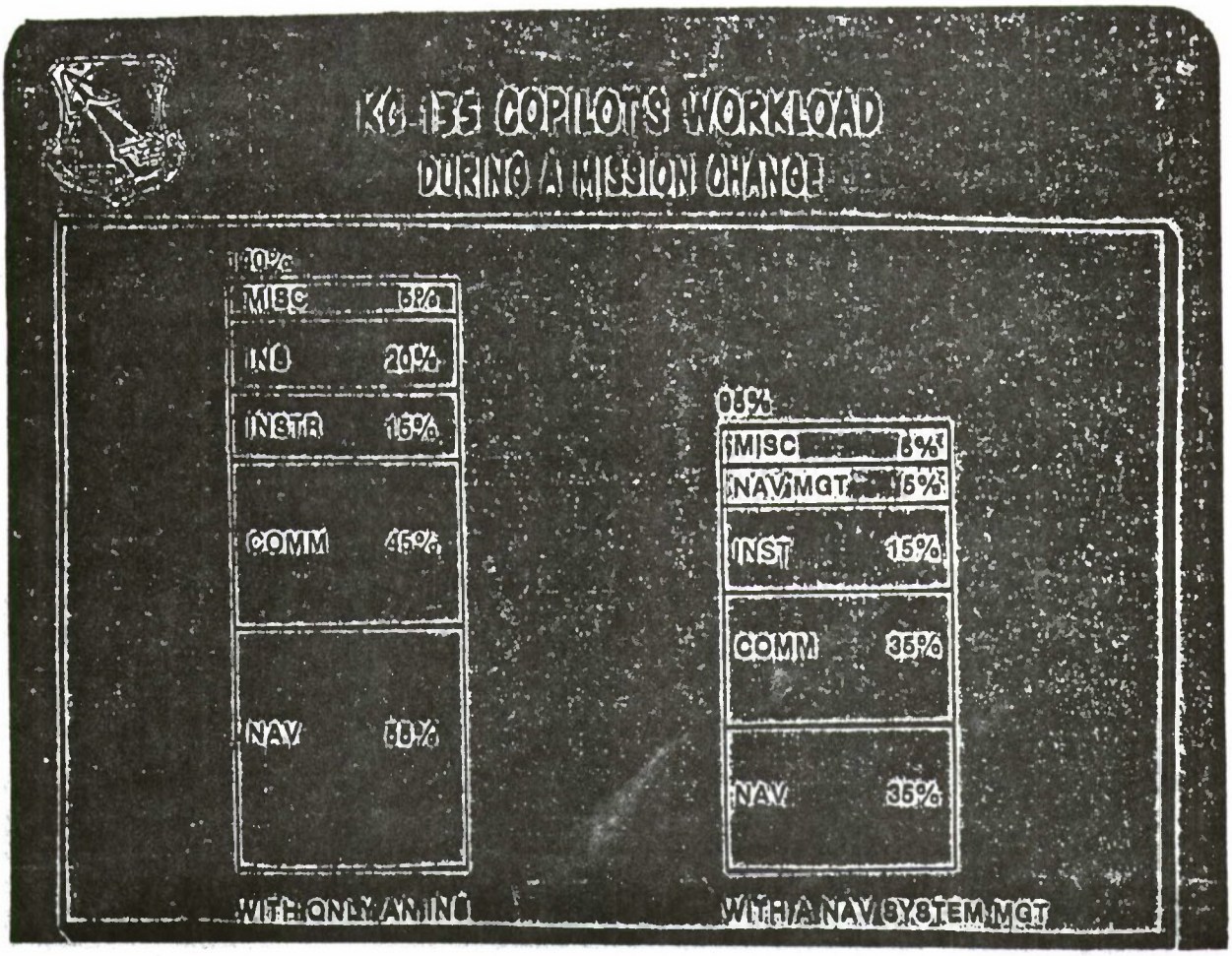
INFORMATION FLOW AND FORMATTING

TACTICAL EVALUATION OF SYSTESM/SUBSYSTEMS

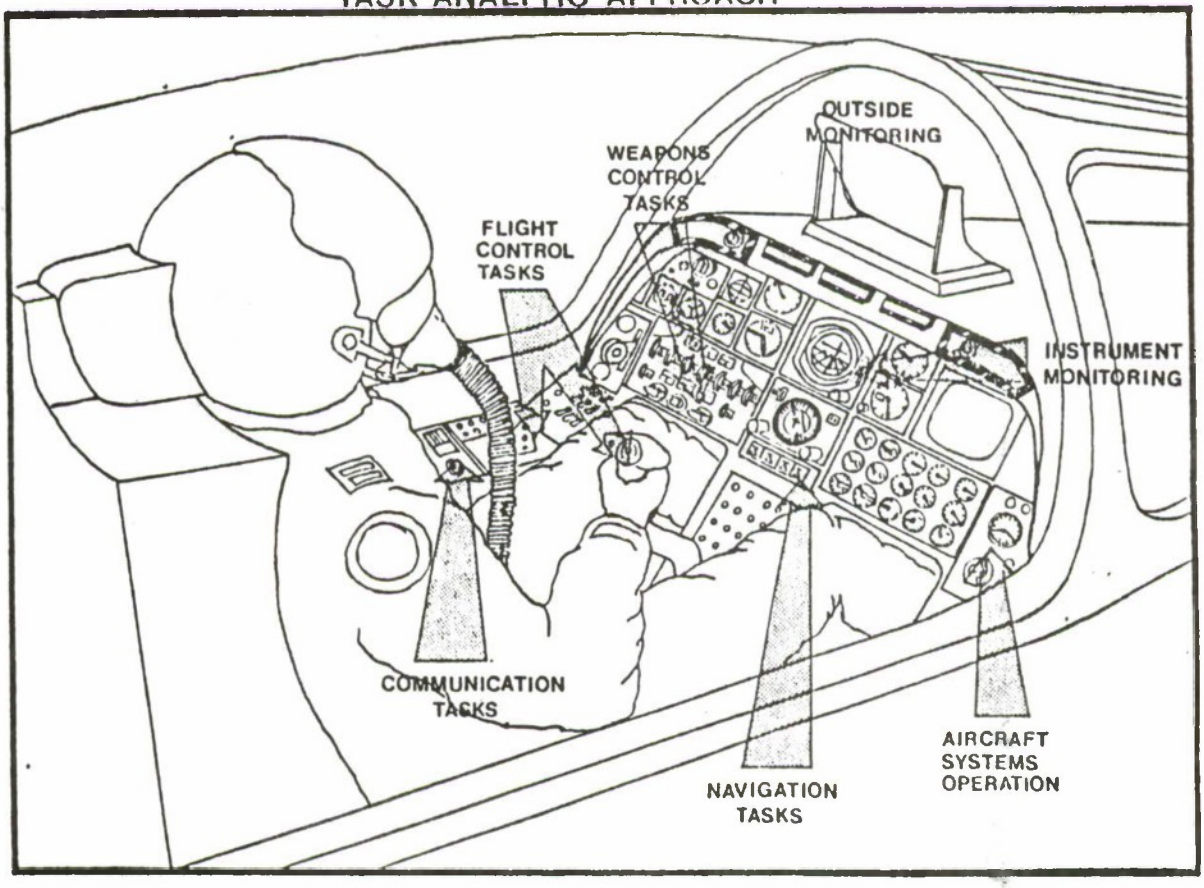
TOTAL HUMAN-MACHINE INTEGRATION

WORKLOAD ASSESSMENT METHODOLOGY

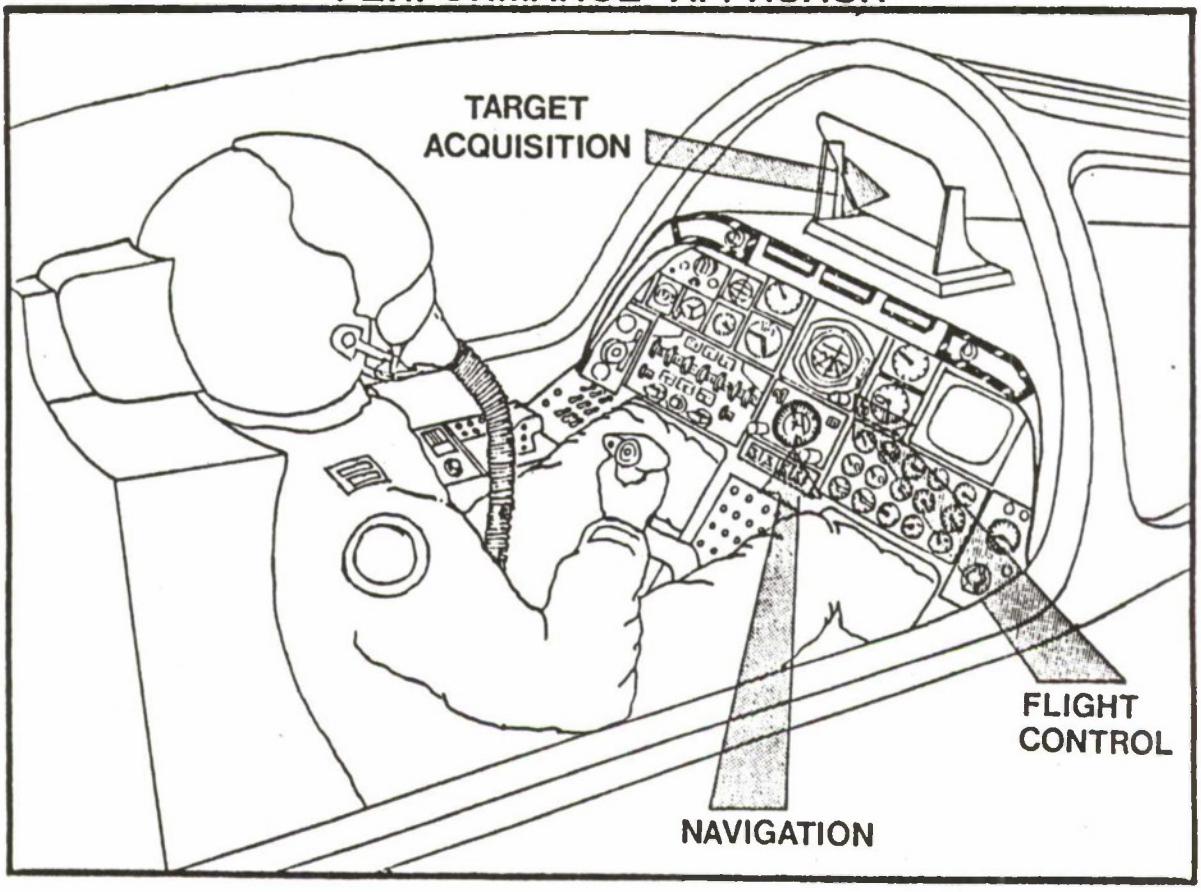
- TASK ANALYSIS
  - DIRECT OBSERVATION
- AIRCRAFT PARAMETERS
  - PRIMARY TASKS
- SUBJECTIVE
  - QUESTIONNAIRES
  - MODIFIED COOPER-HARPER SCALES
  - SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE
- BEHAVIORAL
  - SECONDARY TASKS
- PHYSIOLOGICAL



TASK ANALYTIC APPROACH



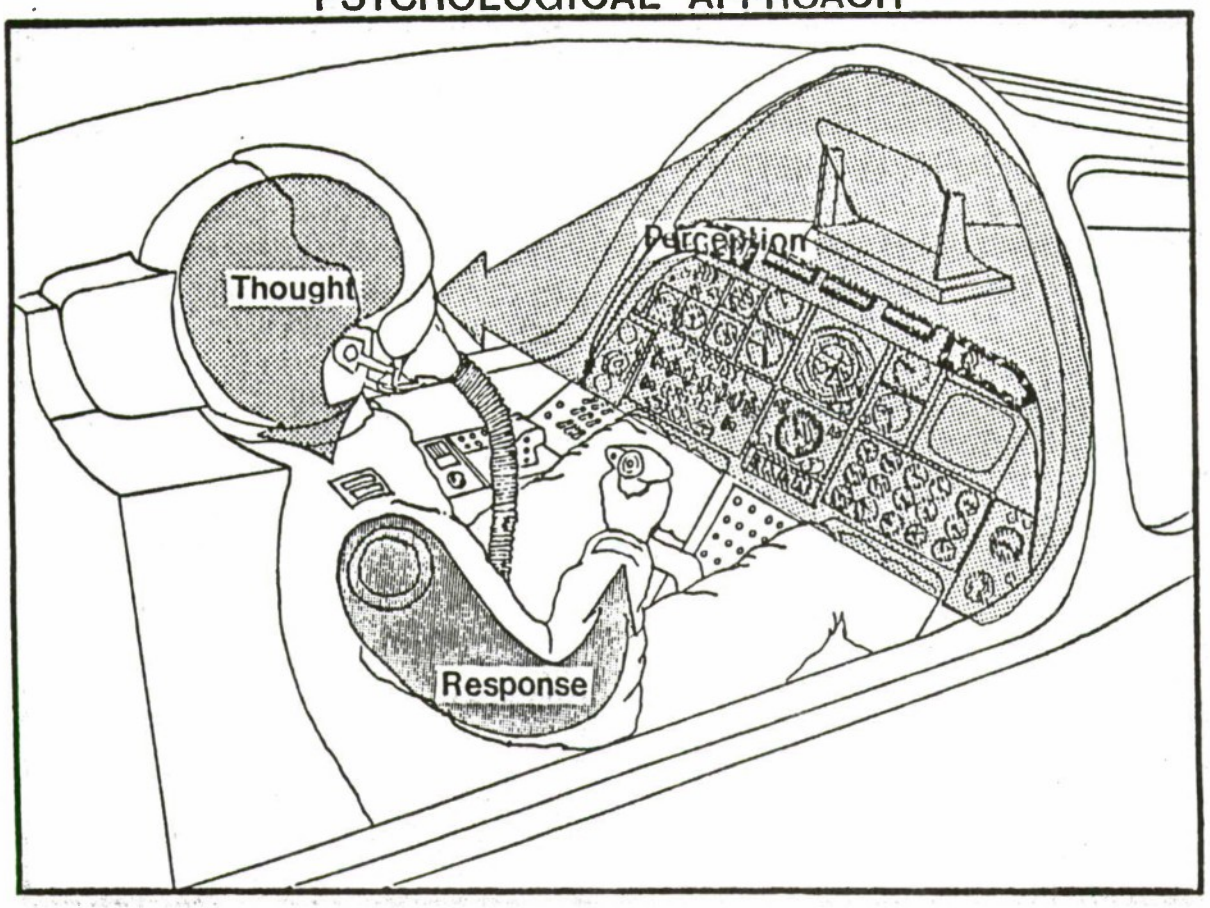
PERFORMANCE APPROACH



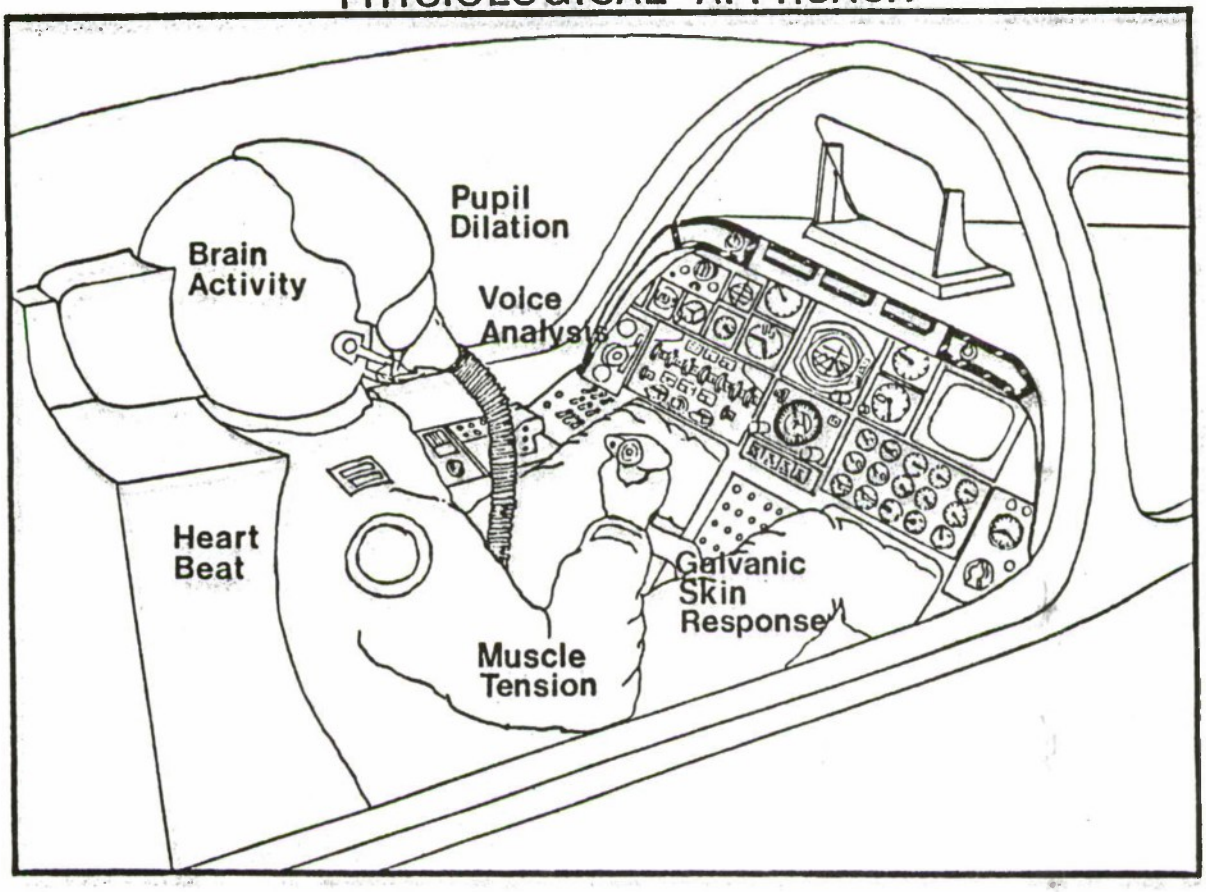
BEHAVIORAL METRICS

- VISUAL STERNBERG TASK
- AUDITORY STERNBERG TASK
- INTERVAL PRODUCTION TASK
- LEXICAL ACCESS TASK
- DISPLAY MONITORING TASK

PSYCHOLOGICAL APPROACH



PHYSIOLOGICAL APPROACH



PHYSIOLOGICAL METRICS

- VISUAL CORTICAL EVOKED RESPONSE
- AUDITORY CORTICAL EVOKED RESPONSE
- EPOCH ANALYSIS OF EEG
- EYE BLINK ACTIVITY

SIMULATOR WORKLOAD MEASUREMENT SYSTEM (SWMS)

- BEHAVIORAL AND PHYSIOLOGICAL WORKLOAD MEASUREMENTS
- HARDWARE/SOFTWARE
- CONTRACT LET FOR PHASE I JULY 1985

PHASE I

- DETERMINATION OF DESIRED TEST CAPABILITIES
- DEVELOPMENT OF UNIQUE HARDWARE AND SOFTWARE
- BREADBOARD DEMONSTRATION AND TESTING
- DESIGN, FABRICATION, INSTALLATION, AND TEST AT CREW STATION DESIGN FACILITY (CSDF)
- DOCUMENTATION OF HARDWARE, SOFTWARE, AND PROCEDURES

SWMS FEATURES

- QUICK AND EASY ADAPTABILITY
- STAND ALONE CAPABILITY
- TIME-CODED WORK LOAD DATA
- SIMPLIFIED OPERATION
  - MENU OPTIONS
  - PROMPTS
- EMBEDDED STIMULUS/RESPONSE INTERFACES

SWMS ADVANTAGES

- STANDARDIZATION
- FLEXIBILITY
- GLOBAL VS SPECIFIC WORKLOAD
  - DIAGNOSTIC

JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM (JTIDS) I O T & E

Colonel Jim Wyman
Air Force Operational Test & Evaluation Center
Eglin Air Force Base

Colonel Wyman talked on the Joint Tactical Information Distribution System (JTIDS). He is presently test director for the initial test and evaluation of this system. The purpose of this system is to be able to accommodate a very high rate of data transmission while providing a secure, anti-jam capability at the battlefield sight.

Enormous quantities of data are transmitted to air defense units, and the units then process the data resulting in a change in mission performance. Colonel Wyman explained that as operational testers it is the job of the center to evaluate the JTIDS Class 2 terminal and determine the change in mission performance when it is owned, operated and maintained by the respective services.

This will be accomplished by plugging JTIDS into an operational environment, not a laboratory environment, in an effort to use it in as realistic a setting as possible. Two aircraft, the F-15A and F-15C will be used for evaluation.

The system works on a time division multiple access architecture. This means that every user has a transmitter, receiver and clock. Each user is assigned a time period when he can transit data and at all other times he can only receive data.

Presently the pilot gets information from a number of sensor sources, but anything external to the cockpit will have to come over the UHF radio. Consequently, the bits and pieces of information are all coming in serially, and one has to stop before the next one can be given. JTIDS allows all the various users, senders and receivers, to be able to transmit this information in parallel. The question is, how does one display this information to the pilot?

Critical in the display of the JTIDS transmitted information is the Multipurpose Color Display. The Multipurpose color display uses five colors to display air defense information. Essentially this is incorporating a whole new method of displaying information. It is not new to the community at large, but it is new to the 150-200 hour F-15 pilot that will be using it. The question is will the pilot be able to take this information and process it, turning it into something useful, something that will improve his mission capabilities.

The test is a 10 1/2 month test broken into 3 segments: 1) man-in-the-loop simulations; 2) flight testing -- to trap perishible data; and, 3) operational exercises. Quantifiable information will come from the simulations comparing the use of JTIDS with situations where JTIDS was not used. Scenarios developed in the first segment will be interwoven through the second segment. The third segment will involve actual mission participation.

The goal is to determine the actual contribution of JTIDS. Colonel Wyman states that to accomplish this goal first it is necessary to define the mission. The mission has been defined as the Air Defense Mission. Next the mission is broken down into key elements, and each element is assigned a quantifiable measure. The evaluation will examine the resultant changes in mission effectiveness. The center will also be looking at the maintainability, reliability, supportability, and availability of the JTIDS Class 2 terminal.

The challenge to the center is trying to equate the change in mission performance with a change in the pilot's situational awareness. In essence, determine the difference between the perception and the reality of the pilot. It is necessary to build some sort of process to assess reality, what is attempting to be transmitted to the pilot, and compare it to what the pilot is actually sensing. Then look at at the end of the mission and examine the discrepancies.

CONTROLLING OPERATOR WORKLOAD IN ARMY SYSTEM DESIGN

Dr. Loren Wurzman
Army Research Institute
El Paso, Texas

This was a "Government Only Session" and the contents will not be published in the minutes. Please contact Dr. Wurzman for any further information.

NEUROPSYCHOLOGICAL WORKLOAD BATTERY

Mary Thiessen
General Dynamics
Fort Worth, Texas

M. Thiessen discussed the Neuropsychological Workload Test Battery Validation Study. This project is being done in conjunction with the Airforce Aerospace Medical Research Laboratory.

The project is comprised of a series of simulator studies to assess pilot workload in a variety of air force environments. Workload is measured by recording and analyzing various physiological signals from the pilot while he performs specific tasks. The goal of the effort is to establish the feasibility, validity, and reliability of specific neurophysiological measures contained in the test battery that is currently being implemented.

To date five studies have been completed. Final results on these studies will be out in 1986, and presently only preliminary results are available. The initial test battery was designed by the department of psychophysiology at the University of Illinois. An LSI 11 based system is responsible for data acquisition, experimental control, and some of the data analysis.

The original test battery was intended to be a field-usable device, but was really too cumbersome for that purpose, and a second generation test battery was built by Systems Research Laboratories at Dayton, Ohio. This system is an LSI 11 73 based system and is much more compact.

The test battery measures included in both batteries were:

- Six Brain Measures:
    1. Auditory evoked response
    2. Visual evoked response
    3. Sternberg paradigm with evoked response
    4. High-Frequency steady state
    5. Steady state evoked response
    6. Brainstem
- One Muscle potential measure:
    1. Electromyographic measure (EMG)
- One Eye parameter measure:
    1. Electrooculographic measure (EOG)
- One Electrocardiographic measure (ECG):
    1. Heart rate/heart rate variability measure.

The first two, the auditory and visual evoked responses, were implemented as a secondary task into the cockpit environment. Actual data on the visual rare event battery item showed clear results for the P300 component. The Sternberg test battery measure combines the traditional paradigm with the P300 evoked response. This measure hasn't been used because of the difficulty implementing it in the pilot environment. The high-frequency steady state measure was a pre and post measure used to dertermine fatigue effects by assessing visual transmission speed. The steady state evoked response was implemented with the subject viewing a monitor with a grid pattern on it. The brainstem measure was also only a pre and post measure and assessed auditory sensitivity.

The EMG was intended not to measure workload directly, but to get a muscle fatigue measure. The EOG was recorded by placing electrodes around the subjects' eye. Some of the EOG parameters examined were rate, amplitude (not too sensitive), 50% descent time, and 50% closure duration. The last two have been more sensitive to workload variations. These measures tend to decrease with increasing workload. The ECG measured inter-beat intervals which were converted to heart rate.

The first two environments used in the study were designed to be very simple and contain 3 levels of workload. The first environment included: 1) a straight and level flying task; 2) normal ILS; and 3) an ILS with degraded handling qualities. The measures that were implemented were the auditory-evoked response, electromyographic measure (EMG), electrooculographic measure (EOG), brainstem measure, and the heart-rate measure (HR). Only the EOG exhibited a statistically significant relationship to the workload levels. Heart-rate measure was not analyzed at this time.

The second environment was a B-52 Tail Gunner environment where the primary task was to fire at targets on a radar scope. The manipulations included the number of targets, frequency of target appearance, and speed of targets, just to name a few. The measures taken were the auditory-evoked response, EMG, EOG, and HR. Again, HR was not analyzed, and only the EOG exhibited a statistically significant relationship to no-load versus load conditions.

Environments three and four were Day/Night Low-Altitude Interdiction Missions conducted in the F-16 simulator at General Dynamics. The primary task was manual terrain following and/or terrain avoidance, and some weapon deliveries on targets. The measures used were the EOG, HR and high-frequency steady state evoked potential (SSEP) which was implemented as a pre and post test. This time the EOG did not come out statistically significant, but heart rate was analyzed and exhibited a sensitivity to low versus high workload conditions.

Environment 5 was and Air-to-Air Fighter Aircraft Intercept Mission where the pilot was told to intercept fighters which appeared on his display. Workload was varied by manipulating the type of enemy aircraft evasive maneuvers, enemy aircraft speed, and initial intercept geometry. The performance measures were time to missile release, part of missile release envelope, and aspect angle of target.

The original concept behind this set of studies was to try to develop cockpit design guidelines. The second generation of this test battery is now being designed from the experience gained using the first generation battery in this set of studies. The final report, coming out in the spring, will contain the results and conclusions drawn from these studies. For instance some of the measures simply could not be implemented into a fighter environment because of the nature of the setting and task demand. Hopefully the physiological methodologies will offer enhanced man-machine interfaces so that a cockpit design methodology that is sensitive to aircrew workload will be available.

NEUROPSYCHOLOGICAL WORKLOAD TEST BATTERY VALIDATION STUDY

AIR FORCE AEROSPACE MEDICAL RESEARCH LABORATORY
CONTRACT NO. F33615-82-C-0517
PROGRAM MANGER: COL. R. D. O'DONNELL

CONTRACTOR: GENERAL DYNAMICS/FORT WORTH DIVISION

NEUROPSYCHOLOGICAL WORKLOAD TEST BATTERY VALIDATION STUDY

DEFINITION:

- SIMULATOR STUDY TO ASSESS PILOT WORKLOAD IN A VARIETY OF AIR FORCE ENVIRONMENTS
- WORKLOAD IS MEASURED BY RECORDING AND ANALYZING NUMEROUS PHYSIOLOGICAL FUNCTIONS OF THE PILOT WHILE HE PERFORMS SPECIFIC TASKS

GOAL:

- ESTABLISH FEASIBILITY, RELIABILITY, AND VALIDITY OF THE USE OF NEUROPSYCHOLOGICAL INDICES AS WORKLOAD MEASURES, ESPECIALLY FOR USE AS A QUANTITATIVE COCKPIT SYSTEM DESIGN TOOL

SCOPE:

- SEVEN SEPARATE STUDIES WILL BE CONDUCTED OVER A PERIOD OF 39 MONTHS; TWO BOMBER STUDIES USING CARSWELL AFB FACILITIES AND FIVE FIGHTER STUDIES, USING GENERAL DYNAMICS FACILITIES, WILL BE CONDUCTED

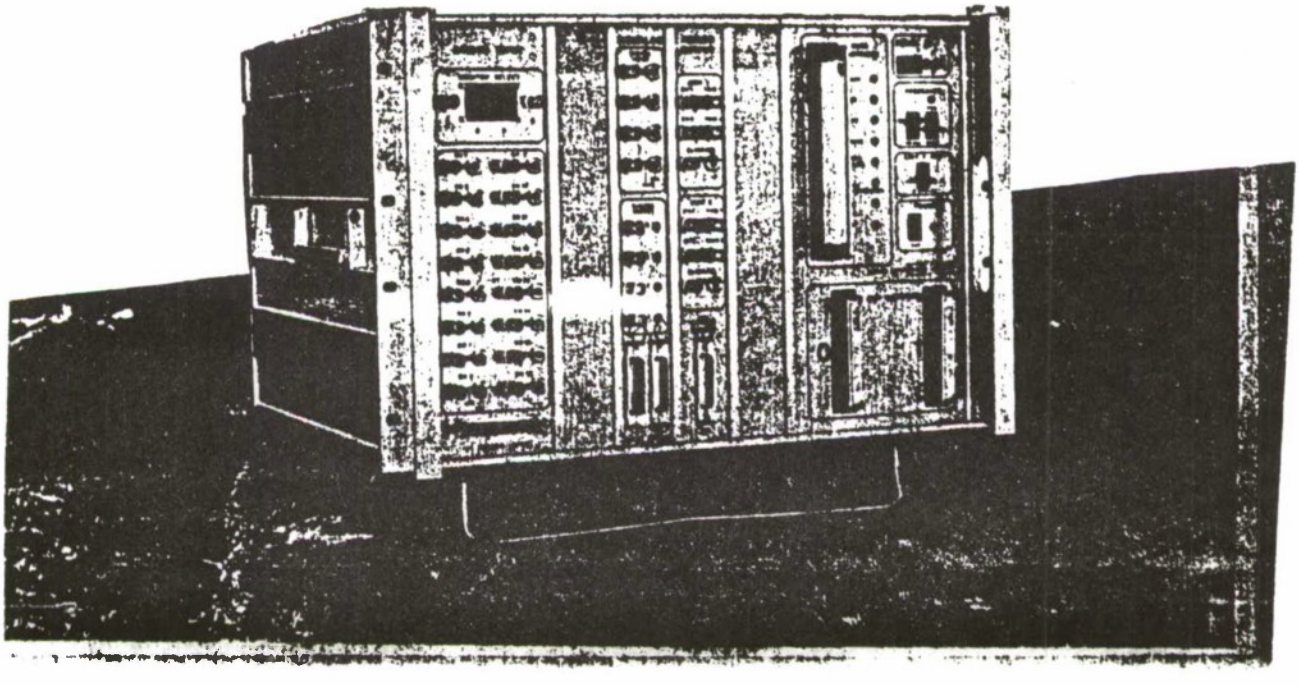
NEUROPSYCHOLOGICAL WORKLOAD TEST BATTERY

(AKA PEARL II)

- DESIGNED AND DEVELOPED BY THE COGNITIVE PSYCHOPHYSIOLOGY LABORATORY, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

- LSI 11 – BASED PSYCHOPHYSIOLOGICAL DATA ACQUISITION/EXPERIMENTAL CONTROL SYSTEM

- CONTAINS NINE DIFFERENT BATTERY TESTS, INCLUDING:
  - Auditory Oddball Test
  - Visual Oddball Test
  - Transient Evoked Response to Visual & Short-Term Memory Tasks
  - Brain Stem Response
  - Steady-State Evoked Response for Threshold Detection
  - High Frequency Steady-State Evoked Response for Measuring Neural Transmission Speed
  - Electromyographic Analysis
  - Eye-Blink/Eye Movement Analysis
  - Measures of Heart Rate Variability



TEST BATTERY MEASURES

- BRAIN (Electroencephalographic) MEASURES
  - ✔ AUDITORY EVOKED RESPONSE
  - ✔ VISUAL EVOKED RESPONSE
  - ✔ STERNBERG PARADIGM W/EVOKED RESPONSE
  - ✔ HIGH-FREQUENCY STEADY STATE (Neural Transmission Time)
  - ✔ STEADY STATE EVOKED RESPONSE (Contrast Threshold)
  - ✔ BRAINSTEM
- MUSCLE POTENTIAL MEASURE
  - ✔ ELECTROMYOGRAPHIC MEASURE
- EYE PARAMETER MEASURE
  - ✔ ELECTROOCULOGRAPHIC MEASURE
- ELECTROCARDIOGRAPHIC MEASURE
  - ✔ HEART RATE/HEART RATE VARIABILITY MEASURE

ENVIRONMENT 1 – B-52 ILS APPROACH

PRIMARY TASK:

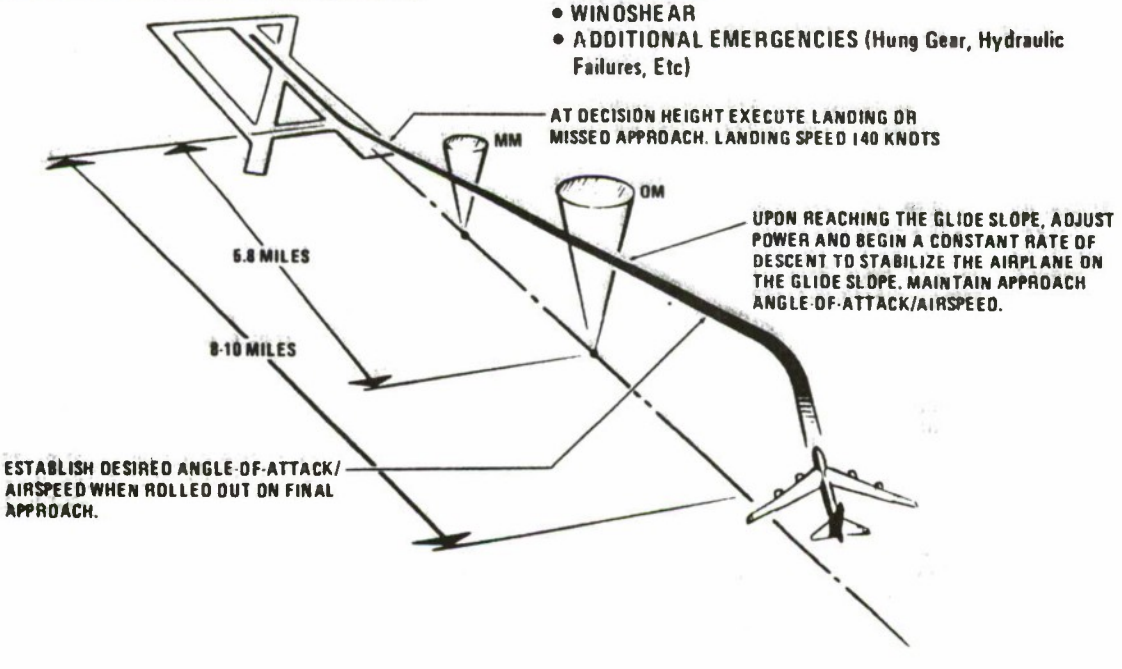
- PILOT PERFORMING ILS APPROACH

PERFORMANCE MEASURES:

- RMS ELEVATION ERROR FROM GLIDEPATH
- RMS AZIMUTH ERROR FROM GLIDEPATH

PARAMETERS AVAILABLE TO VARY WORKLOAD:

- HANDLING QUALITIES OF AIRCRAFT
  - ✔ Engines Out – One Side
  - ✔ Split Flaps
  - ✔ Runaway Trim
  - ✔ Aircraft Loading
- CROSS WINDS
- WINDSHEAR
- ADDITIONAL EMERGENCIES (Hung Gear, Hydraulic Failures, Etc)



STUDY 1 SUMMARY

TEST BATTERY MEASURES*	RESULT
• AUDITORY-EVOKED RESPONSE	• PATTERN SEEN, BUT ANALYSIS ALGORITHM SUSPECT
• ELECTROMYOGRAPHIC MEASURE (EMG)	• NO SENSITIVITIES
• ELECTROOCULOGRAPHIC MEASURE (EOG)**	• SENSITIVE TO LOAD vs. NO-LOAD; STATISTICALLY SIGNIFICANT
• BRAINSTEM MEASURE	• NO SENSITIVITIES
• HEART-RATE MEASURE (HR)	• NO SOFTWARE AVAILABLE

Original Instrumentation
**Subcontractor S/W*

ENVIRONMENT 2 – B-52 TAIL GUNNER

PRIMARY TASK:

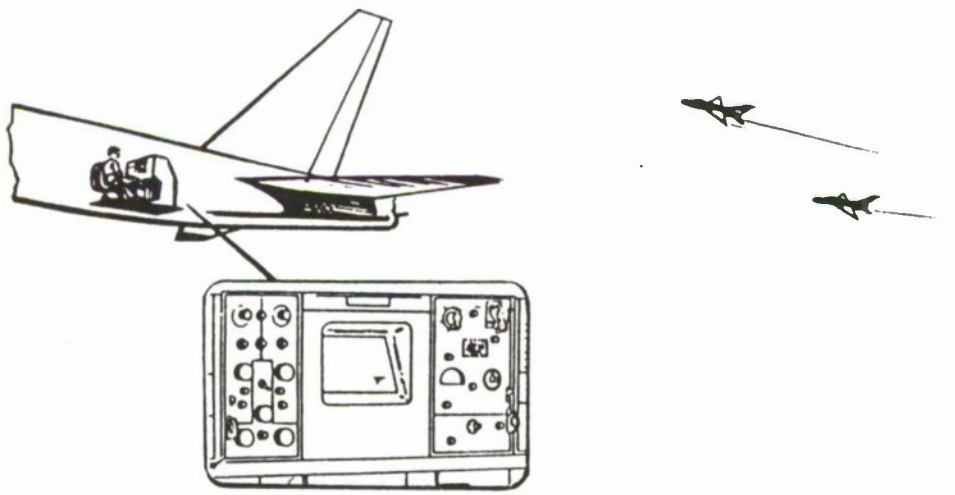
- TAILGUNNER ACQUIRES TARGET ON RADAR SCOPE; SLEWS CURSOR TO TARGET; FIRE

PERFORMANCE MEASURES:

- INSTRUCTOR EVALUATION

PARAMETERS AVAILABLE TO MANIPULATE WORKLOAD

- NUMBER OF TARGETS
- FREQUENCY OF TARGET APPEARANCE
- SPEED OF TARGETS
- AUTO/MANUAL MODES OF OPERATION
- RELATIVE VECTOR OF TARGETS
- TARGET DISCRIMINABILITY/DIFFICULTY IN PRIORITIZATION



STUDY 2 SUMMARY

TEST BATTERY MEASURES*	RESULT
• AUDITORY EVOKED RESPONSE	• NOT STATISTICALLY SIGNIFICANT
• EMG	• NO SENSITIVITIES
• EOG**	• DISCRIMINATED LOAD vs. NO-LOAD; STATISTICALLY SIGNIFICANT
• HR	• NO ANALYSIS SOFTWARE

*Original Instrumentation
**Subcontractor S/W

ENVIRONMENTS 3,4 – DAY/NIGHT LOW-ALTITUDE INTERDICTION MISSION

PRIMARY TASK:

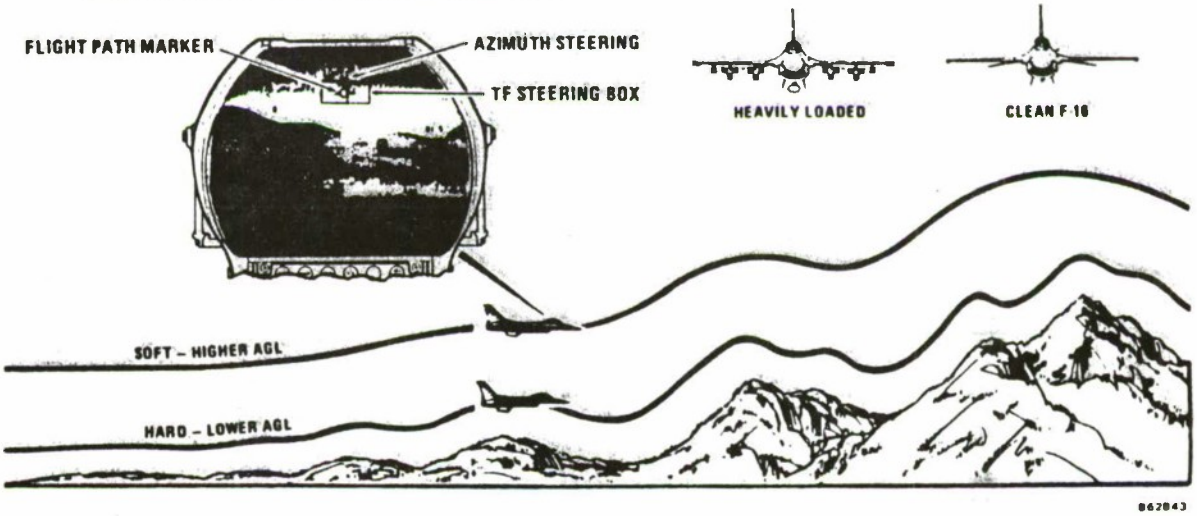
- MANUAL TERRAIN FOLLOWING AND/OR TERRAIN AVOIDANCE

PERFORMANCE MEASURES:

- RMS ERROR FROM IDEAL ALTITUDE PROFILE
- HEADING RMS ERROR
- GROUND IMPACTS
- EXCURSIONS OUTSIDE ACCEPTABLE AGL BAND

PARAMETERS AVAILABLE TO VARY WORKLOAD:

- TERRAIN (Flat to Very Mountainous)
- VISIBILITY (Daylight, Fog/Haze, Night)
- AIRCRAFT SPEED
- AIRCRAFT TF ALTITUDE
- AIRCRAFT HANDLING QUALITIES (Loading)
- RIDE PARAMETERS (Soft to Hard)



STUDIES 3/4 SUMMARY

TEST BATTERY MEASURE*	RESULT
• EOG**	• NOT STATISTICALLY SIGNIFICANT
• HR	• SENSITIVE TO LO vs. HI WORKLOAD; STATISTICALLY SIGNIFICANT
• HIGH-FREQUENCY STEADY STATE EVOKED POTENTIAL (SSEP)	• NO FATIGUE EFFECTS

*Replacement Instrumentation
**Test Battery S/W

ENVIRONMENT 5 – AIR-TO-AIR FIGHTER AIRCRAFT INTERCEPT

PRIMARY TASK:

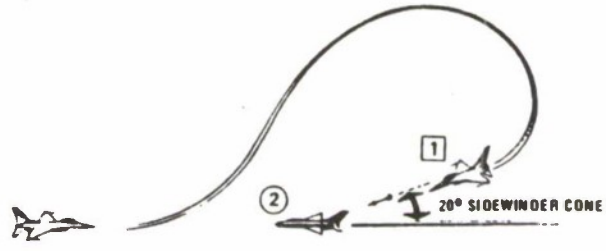
- INTERCEPT FROM BVR TO VISUAL RANGE WITH AIM-9L LAUNCHES

PERFORMANCE MEASURES:

- TIME TO MISSILE RELEASE
- PART OF MISSILE RELEASE ENVELOPE
- ASPECT ANGLE OF TARGET

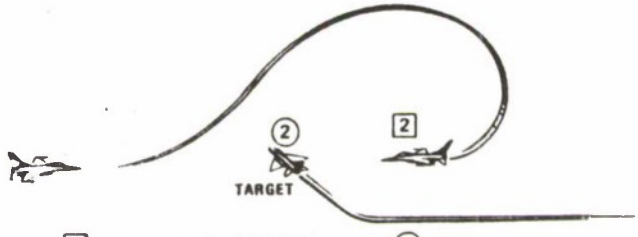
PARAMETERS AVAILABLE TO VARY WORKLOAD:

- ENEMY AIRCRAFT EVASIVE MANEUVERS (None to Three-Dimensional)
- ENEMY AIRCRAFT SPEED
- INITIAL INTERCEPT GEOMETRY



[1] INITIAL HEAD-ON INTERCEPT, FORCE ASTERN CONVERSION

(2) NO EVASIVE MANEUVER



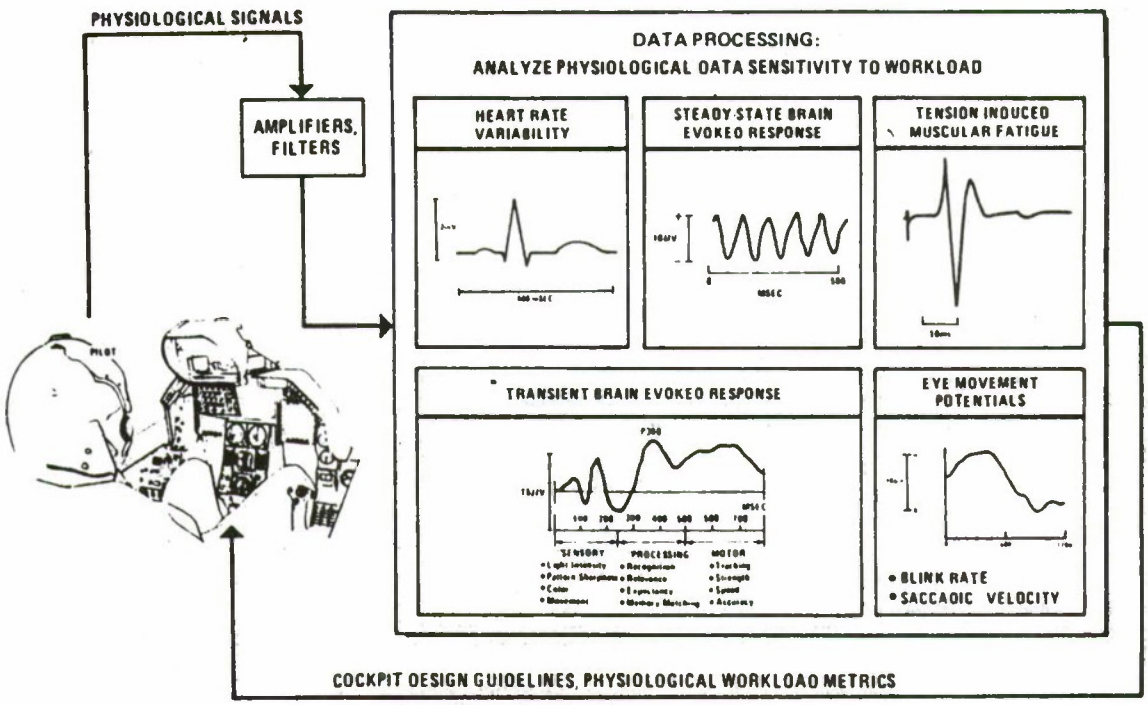
[2] INITIAL HEAD-ON INTERCEPT, FORCE ASTERN CONVERSION; FOLLOW TARGET EVASIVE MANEUVER UNTIL TARGET IS WITHIN SIDEWINDER 20° CONE; FIRE AIM-9L

(2) 45° ANGLE, LEVEL EVASIVE MANEUVERS; TURN IN DIRECTION A/C IS APPROACHING FROM TO AVOID LAUNCH ENVELOPE

[3] INITIAL HEAD-ON INTERCEPT, FORCE ASTERN CONVERSION; FOLLOW TARGET EVASIVE MANEUVERS UNTIL CAN FIRE AIM 9L

(3) TARGET PERFORMS COMPLEX 3-DIMENSIONAL EVASIVE OR JINKING MANEUVERS

NEUROPSYCHOLOGICAL WORKLOAD TEST BATTERY VALIDATION STUDY



- TECHNOLOGY INVOLVED IN THE NEUROPSYCHOLOGICAL WORKLOAD TEST BATTERY OFFERS ENHANCED MAN-MACHINE INTERFACES THROUGH DESIGN OF COCKPITS THAT ARE SENSITIVE TO AIRCREW WORKLOAD

OVERVIEW OF THE HUMAN PERFORMANCE ASSESSMENT RESEARCH GROUP

Sandra G. Hart, Leader
Human Performance Assessment Research Program
NASA-Ames Research Center

BACKGROUND

The Human Performance Assessment Research Group was formed in October 1982, although isolated work in this area had been performed previously. It has focused on developing generic concepts and techniques to measure and predict workload and performance and applying them to operationally relevant problems posed by individuals from other ogranizations within NASA, other government agencies, industry, and universities. Generic research has been accomplished through literature review, theoretical development, laboratory and simulation research, and inflight experimentation. Operational problems have been addressed through technical publications, consultation, and collaborative research.

Increasing emphasis has been placed on integrating and extending the results of theoretical predictions and empirical research about human performance and cognition with mathematical models and analytic structures. The validity and practical relevance of the models and structures are evaluated in operational settings as the opportunities arise. These activities often address specific operational problems, although some are simply conducted in an operational environment to provide contextual relevance.

The initial goal of the program was to develop measures and predictors of human performance and workload. To accomplish this objective, a conceptual framework was developed in which the relationships among task-related, operator-related, and performance-related variables were hypothesized. The underlying assumption was that performance and workload are complex constructs that each reflect many variables in addition to task requirements and observable behavior. Although variations in workload and performance are often directly related, there are many instances in which they are influenced by different factors. Since each reflects different, important, aspects of the successful operation of a man-machine system, predicting, assessing, and modifying both workload and performance, and their interactions, have been studied and delineated. The typical approach has been to to conduct inhouse research and to fund several parallel, theoretically different lines of research in each area activities with grants or contract. The research efforts are coordinated through working meetings involving all program participants, quarterly distribution of research proposals, reports, and papers written by all participants, providing common experimental paradigms and tasks against which different approaches can be tested, and interactions at scientific meetings. More formal integration of the disparate research elements has been accomplished by informal program overviews written each year, published reviews of specific areas (such as a recent chapter on the "Theory and Measurement of Human Workload") and an analytic structure that is under development at Ames designed to predict the workload and performance of different operational scenarios.

Three general program area will be described below. They are: (1) assessment techniques for workload and performance, (2) predictive methods for workload

and performance, and (3) training strategies in which workload and performance assessment are included as an integral design element.

ASSESSMENT TECHNIQUES

The development of valid and reliable workload measurement techniques was established as the first priority of the program, as this seemed to be the most pressing requirement of the aerospace community and as a logical precursor to other program elements. Although the focus was on workload, appropriate measures of performance were developed in parallel, and comparisons were made among the various measures of both worklod and performance. The measurement areas studied included:

1. Subjective ratings by operators and observers
2. Physiological correlates
3. Primary and secondary measures of precision and speed
4. Descriptive analytic structures
5. Communications and discourse analyses

In each area, the most promising techniques were selected from among those already in use and others were developed. The candidate techniques were subjected to comparative evaluations in laboratory and simulation environments to determine their potential utility, identify unresolved research issues, and refine the most promising ones. In-house research, university grants and research contracts were funded to allow experts from a variety of disciplines (e.g., psychology, physiology, engineering, mathematics) to resolve theoretical and practical problems associated with the use of the selected measures.

As an example, subjective ratings were an early focus of attention because the technique has face validity, it is the most widely and practically applicable measure, and has been used as the ultimate validation of most other measures. Some of the theoretical and practical issues studied included:

1. Individual differences (a priori biases; subjective experiences)
2. Design (single/multiple dimensions; conceptual or concrete anchors; continuous/discrete categories; "fuzzy" or "crisp" descriptors)
3. Timing (on-line/retrospective; cued/free recall)
4. Correlation with other measures (performance/effort/physiological variables/model predictions)

Empirical information was obtained about each issue and practical solutions were devloped and tested. An example of one such solution to the problem of individual differences is the following:

PROBLEM: Large individual differences in workload ratings are obtained from individuals who have experienced apparently similar situations.

HYPOTHESIS: Differences in a priori definitions of "workload" (e.g.,

"effort", "task difficulty", "success/failure", "stress", etc) cause different raters to react to and evaluate different aspects of a task.

SOLUTION: Commonly held definitions of "workload" were identified. A technique was developed to identify the relative importance of each one (e.g. its weight) to a specific operator. These weights determined the relative contribution of each workload-related dimension to a mathematically derived workload rating.

VALIDATION: Twenty five laboratory, simulation, and inflight experiments were conducted using this technique. The derived workload rating was compared to traditional subjective workload measures (e.g., Cooper-Harper Rating Scale for Aircraft Handling Qualities, the Subjective Workload Assessment Technique developed by the USAF, and unidimensional ratings), as well as to other measures of workload and performance (e.g., reaction time, response precision, heart rate, heart rate variability, blood pressure variation, evoked cortical potentials, secondary task performance, etc). In every experiment, between-rater variability was reduced by at least 20% (and often by as much as 50%) and the percent of variance accounted for by the experimental variables was increased.

APPLICATIONS: For this assessment technique, as for the others, the next step is application to operational problems and publication in the open literature. Even though, it is assumed that validated measures will be sufficiently general that the information they provide will be consistent when they are used appropriately, a subject-matter expert might be required to insure that the measure or analytic technique is applied appropriately and that reasonable conclusions are drawn when measures are applied to specific vehicles or operational tasks. Thus, virtually all operational validations have been performed in collaboration with outside organizations.

Again using the derived workload rating as an example, researchers at Johnson Space Center requested support in conducting a 1-g evaluation of two alternative space suit designs with respect to upper body mobility and fatigue. A battery of laboratory tasks developed at Ames were provided as a focal point for the behavorial portion of the suit-testing research, and a computerized version of the subjective evaluation technique was provided. This interaction not only allowed researchers at Johnson to take advantage of the wealth of experience already obtained at Ames with the tasks and the measures, but also allowed Ames researchers to apply these measures in an interesting and unusal environment. The logical next step would be to follow the introduction of the final suit design into space, obtaining performance and workload measures under a variety of circumstances to evaluate the impact of the suit design in different environments on the astronauts. This study has been proposed for an upcoming Shuttle flight in collaboration with MIT.

Finally, a chapter is in progress for Human Mental Workload and an AGARDoGRAPH in which all of the applications of the rating technique will be summarized to facilitate wide dissemination of the method and its applications.

PREDICTIVE METHODS

In laboratory, simulation, and operational settings, a standardized way to create operationally relevant tasks that impose known, quantified levels of workload. is needed In research environments, this capability is needed to

create controlled, predictable, experimental situations against which candidate measurement techniques or model predictions can be evaluated or alternative equipment designs tested. In applied settings, the need to predict the workload of advanced systems is particularly critical during the design phase. Information about whether or not a "typical" operator or team of operators will be able to perform the proposed tasks with acceptable levels of workload (given the resources that will be available) is often a key issue.

Many models of human operators exist, however, most are based on a task or time-line analysis of the elemental activities to be performed. Workload levels are typically defined as the ratio between the time required to perform tasks and the time available. Since the subjective experience of workload may involve a wealth of factors in addition to the time pressure element, and task integration and time sharing are certainly possible with experience, additional factors must be included to derive a more accurate workload prediction. In addition, the detailed nature of most time-line and task analytic approaches is not easily extended to alternative systems or different levels of training. Finally, traditional techniques typically evaluate a new system in comparison to a simular existing system. The same procedures may be difficult to apply to entirely novel systems, that will operate in unusal environments, or perform unique missions.

Some of the predictive models under investigation include:

1. Petri net structures for workload prediction (UCLA - John Lyman)

2. Application of Fuzzy Set mathematics to the analysis and prediction of workload and performance (U. of Toronto - Moray)

3. Stochastic models of workload and performance (Purdue - Townsend)

4. Supervisory control models of operators of complex systems (MIT - Sheridan)

5. Computer-based models to predict operator workload, performance, and task duration (Inhouse - Hart/Shively)

In some cases, the modeling efforts have been based on similar theoretical models of workload (e.g., Rasmussen's division of activities in to skill-based, rule-based, and knowledge-based tasks that impose increasing levels of workload) or have used the same experimental task (e.g, the "POPCORN" supervisory control task developed at Ames). The benefit of these overlapping efforts is obvious; comparisons can be made between measures and model predictions and information about the underlying processes can be derived from different perspectives.

A preliminary version of a flight-task workload and performance prediction model has been developed at Ames. It shows great promise in the prediction of workload and performance levels of general aviation flights conducted under instrument flight rules. It will be described below as one example of the research in progress in the area of prediction:

PROBLEM: There is an urgent need for a standardized technique to create simulation scenarios that will impose a predictable, independently determined level of workload on pilots or crews of pilots. Such scenarios are needed for

both research (e.g., for validation of candidate measures of workload and performance) and operational environments (e.g., as a baseline to compare alternative instrument designs or procedures).

HYPOTHESIS: The workload, duration, and performance of most well-learned tasks is remembered, experienced, and measured most effectively in terms of functionally integral units (e.g., the landing segment of flight). Variations in workload, duration, or performance may be created by imposing additional activities on operator(s), modifying the environment, or changing the time constraints within which the task is to be performed. In addition, the actual workload experienced by an operator during the performance a specific scenario can be analyzed, post hoc, by computing the number and types of additional tasks or states that occurred coincidentally during the flight relative to the intended levels.

SOLUTION: A computer program is being developed in which the functional units of instrument flight are identified and the nominal durations, performance and workload levels, and the transitions from one to another are determined. This program accesses a data base in which the logical variations of events or states that might occur are enumerated. Finally, the algorithms by which different tasks or states can be combined with each nominal segment have been derived empirically. In order to create a simulation scenario with this model, the length of the desired scenario and the number of take-offs and landings will be entered by the user. The program computes a nominal scenario from this information which can be accepted or modified. For each segment, a menu of logical events that can be added or enrivonmental variations that can be imposed are presented. As the user selects different options, the predicted levels of workload, performance and duration are modified and displayed graphically and numerically until the user has created a scenario with the desired characteristics.

VALIDATION: A paper-and-pencil version of the model has been tested with a large data-base of workload and performance levels for routine flight segments and flight-related events. These have been combined to create candidate flight scenarios which have been flown in a GAT-I simulator. The model predictions have been tested with a number of subjective, secondary-task, and performance-based measures of workload in four simulation studies. In most cases, the empirical results support the the model's predictions.

APPLICATIONS: In the near term, the paper-and-pencil version of the model will be programmed to allow simulation scenario creation by computer. The initial test of the computerized model will be accomplished with a simulation in the GAT-I simulator to be consistent with earlier work. The next application planned is for helicopter nap-of-the-earth flight with military missions projected for the 1990s. The focus will be on the LHX helicopter proposed for Army use in the 1990s. It will address such issues as one- versus two-crewmember operations. The model validation studies for the helicopter application will be conducted at Ames in the Vertical Motion Simulator and in conjunction with the Army Simulation Working Advisory Group.

Additional applications will focus on the space station, with early development efforts taking advantage of similar activities performed in shuttle operations. A predictive model of workload and performance for the RMS (Remote Manipulator System) will be programmed using the model structure developed for aircraft and helicopters. It is anticipated that the structure

and algorithms will be similar across applications, although the data bases (e.g, nominal tasks, transiitons, events, environments, and durations) will be task-specific. For the RMS research, the data base will be provided by Johnson personnel, and preliminary testing will be accomplished at Ames in the space station mock-up. Final testing will take place at Johnson in the RMS simulator.

TRAINING STRATEGIES

For the purposes of this program, fulfilling the requirements of any mission is characterized in terms of different "costs":

1. System resources required
   a. Hardware
   b. Software
   c. Personnel

2. Training required
   a. Initial system familiarization
   b. Recurrent training
   c. Transition training between versions or positions

3. Operator workload
   a. Stress
   b. Fatigue
   c. Job satisfaction
   d. Reserve capacity for emergencies, additional tasks

4. System performance
   a. Time to complete tasks
   b. Precision
   c. Safety margin

It is assumed that these "costs" are related, that one may be traded off for another and that relationships among them vary across elements of an overall mission. For example, if sufficient training is provided, a task may be accomplished with acceptable performance and workload levels, few operators, and unsophisticated equipment. If training is limited or crew size reduced, however, then higher workload or reduced performance might have to be accepted unless additional resources are provided (e.g. computer-based automation).

Training is typically accomplished to: (1) familiarize an operator with a new or modified system; (2) enhance performance; or (3) reduce unacceptable workload levels. The relationships among training, workload, and performance are assumed, but few research efforts have focused on the nature of this interrelationship nor their joint measurement. The development of training requirements, strategies, and programs should be integral to the development of any new system. For example, if the training required to achieve acceptable levels of performance is prohibitive for a proposed confinguration, then alternative solutions such as computer aiding, additional crew members, or revised hardware or procedures might be considered early in the design process.

To design an appropriate training method, many issues must be addressed:

1. Where to focus training time and money
2. Operator qualifications
3. Similarity of proposed system to existing systems
4. Part-task versus whole-task training
5. Re-integration of trained part-tasks
6. Optimal workload during training to maximize effectiveness

Whenever a task is performed, specific abilities as well as a general knowledge base are required. Operators experienced on similar systems or tasks may require less training because they can use established patterns of responses, adopt more efficient strategies, and exert appropriate effort in a timely way, thereby minimizing workload. In addition they are more likely to perceive task goals and performance criteria correctly. It is difficult to predict skilled performance on a task from its initial performance; general learning skills may be different than those required for skilled performance on a specific task and skills develop at different rates for different operators and subtasks.

An extensive literature has developed in the last decade around the question of what attributes of practice are essential for improving performance. In general, the conclusion has been that practice must emphasize consistent repetition of tasks having manageable levels of difficulty. To magnify the consistency and insure that training elements are manageable, complex tasks are traditionally decomposed into smaller subtasks. The intention of subtask training is to develop performance "automaticity" which is characterized by improved performance quality and stability. As performance of each subtask reaches an acceptable level, it is re-combined into the original complex task. An important question that remains unanswered is whether or not a standardized criterion can be used to specify subtask elements for training. To date, this process has been more art than science.

Ordinary experiences suggest that task demands and required effort <u>seem</u> to decrease with practice. Subjectively, it is common to expect that practice will reduce the experience of workload. For example, novice drivers concentrate on every aspect of control: where to look, how much control to apply, when to shift, etc. Their workload is high, the safety margin is poor, and their ability to attend to additional information or unexpected situations is limited. In contrast, experienced drivers are unaware of most elemental driving tasks; they perform them "automatically. Subjectively, this is characterized by a dramatic reduction in conscious decision-making and control, and, therefore, in workload. Performance quality and safety margin are high and additional information or unexpected events can be handled readily.

Training enables parallel processing, development of "automatic" behaviors, coordinating previously unrelated activities, and a reduction in conscious decision making. Experts tend to think in terms of larger units of activities to avoid being buried in minutiae. They complete subtasks with minimal attention, recognize patterns of information and initiate sequences of actions with

single decisions. They develop mental models of the system that allow them to predict future states from present evidence or past experience, reducing the need to monitor system status on a moment-to-moment basis. Finally, the occurrence of unexpected events or failures during system operation may affect skilled operators differently than unskilled. They may disrupt sequences of automatic behaviors for skilled operators (thereby increasing workload). Alternatively, skilled operators can more readily recognize and recover from their own errors and system failures. All of this suggests that the workload of experienced operators may be substantially different than that of novices and that one measure of the success of a training program might be to achieve target worklod levels as well as reaching established performance criteria. Obtaining objective evidence for and measurement of these relationship is necessary to design training programs for new and existing systems and to identify where additional training might be beneficial.

Thus, in both the workload and performance domains, a phenonenon that can be termed "automaticity" has been suggested as one explanation for changes that accompany practice. However, it has not been demonstrated that performance and workload reflect training program strategy manipulations similarly. In addition, the levels of workload imposed during training may influence the effectiveness of a training program. Traditionally, workload assessment has been used to compare display and control alternatives and to certify complex systems for operational readiness. This research, however, is intended to explore the utility of workload assessment in a new domain: training design. If successful, the increase in training efficiency chould be substantial.

One example of preliminary research that has been conducted in the area of is that conducted by Dr. Vidulich at Ames, described below:

PROBLEM: Training is essential to insure acceptable levels of both performance and workload in an operational environment. Yet, no systematic empirical investigation into the interaction between operator workload and level of training has been undertaken.

HYPOTHESIS: Both performance improvement and workload reduction resulting from a training program should be proportional to the degree of cognitive automaticity obtained on the target task.

VALIDATION: A classification task was presented with an extended training program followed by a transfer-of-training study from an auditory to a visual presentation mode. The expected performance improvement occurred and it appeared that subjective ratings of workload reflected an improvement with training and upon transfer to a different input modality.

A second experiment will manipulate task parameters so as to influence the amount of performance improvement achievable through practice, replicating manipulations valided in earlier research. The goal will be to determine whether subjective ratings of workload are sensitive to the training-related task manipulations and covary with measures of performance.

APPLICATIONS: A simulation of an orbital maneuvering task will be utilized as an example of a complex, operational task. It is sufficiently demanding to require subtask training. The size and duration of each training element will be defined by either a traditional task analysis decomposition and performance appraisal or by creating challenging yet manageable levels of

workload with different subtasks or groups of subtasks. In this way, the value of workload assessment for training program design can be evaluated.

In order to contribute to an improvement in training strategies, this program will devote a substantial part of its efforts to the development of a interactive, on-line technique for measuring the effectiveness of training programs, variation in different aspects of performance, and operator workload. The optimal way to accomplish this goal is to create a university "center of excellence" where research is ongoing in man/machine integration, automation, workload assessment, and training. Parallel research would be conducted at Ames using theoretical, empirical, and part-task simulation techniques. Validation studies would be accomplished through field studies focused on a variety of applications. If expertise in all of these areas could be integrated and focused on this research area, rapid progress may be expected in resolving the numerous and important questions that remain in this area.

SUMMARY

In summary, the Human Performance Assessment Research Group has been created to understand, assess, and predict the effects of task demands, the environment, and training on operator workload and performance. The approach has been characterized by generic research to discover the underlying principles, the development of assessment techniques, and the evolution of predictive methodologies. Fundamental research has been coupled with vehicle-specific applications of generic concepts and methods to general aviation and transport operations, rotorcraft activities, and space in collaboration with many organizations. Research has been conducted inhouse with empirical laboratory and simulation studies and through university grants and research contracts. There has been a concentrated effort to promote interaction and integration among the research efforts through working metings, exchange of written reports, and published reviews of specific program areas. The work conducted by this group will continue to be relatively fundamental although it will address applied problems posed by a variety of outside organizations as the opportunities arise. In the future, it is expected that emphasis will shift from methods of assessment toward predictive models and integrating earlier findings with other research areas that are of particular interest to the aerospace community (e.g., training, automation, electronic crewmember).

NASA-AMES WORKLOAD RESEARCH PROGRAM

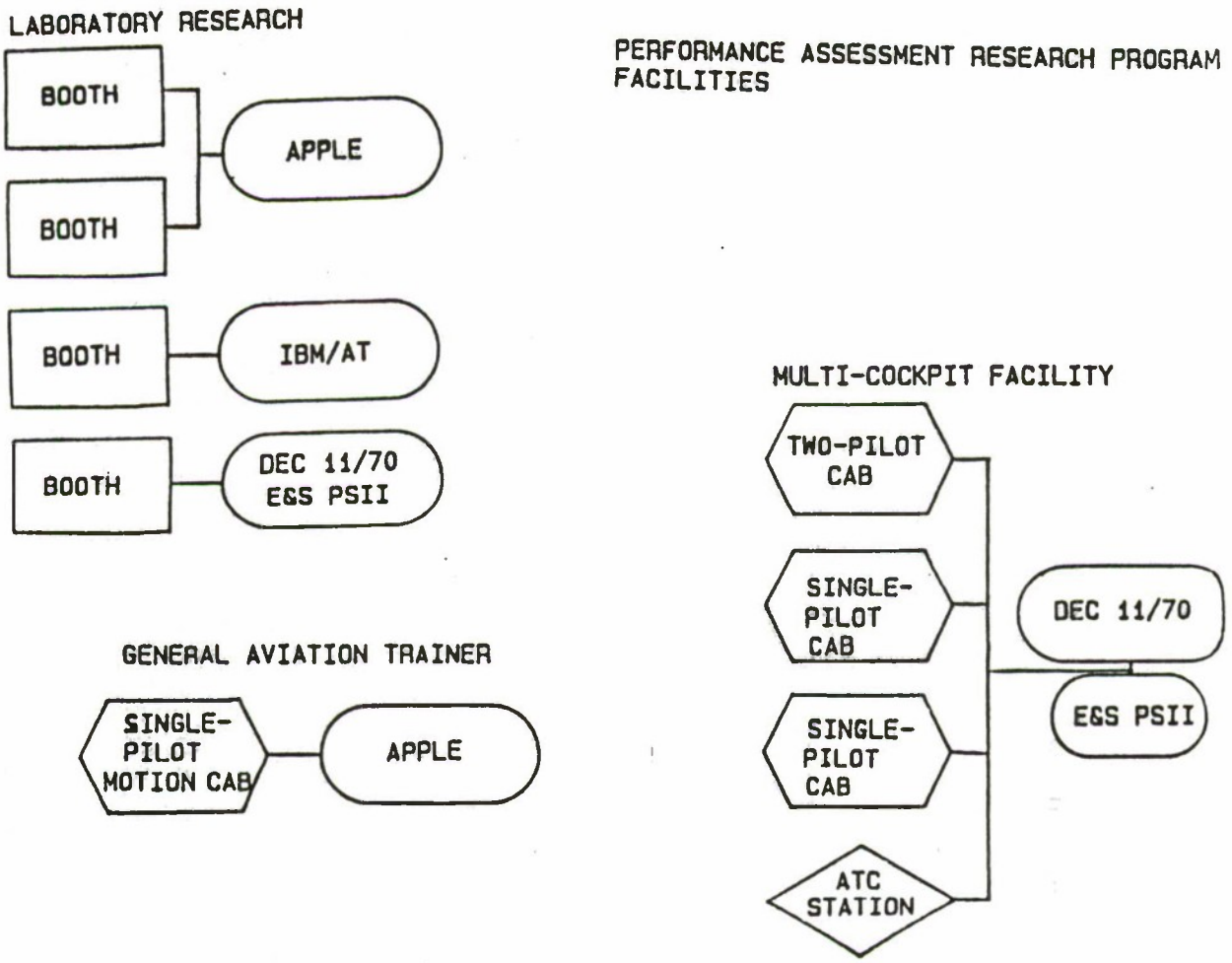
PROGRAM OBJECTIVE:

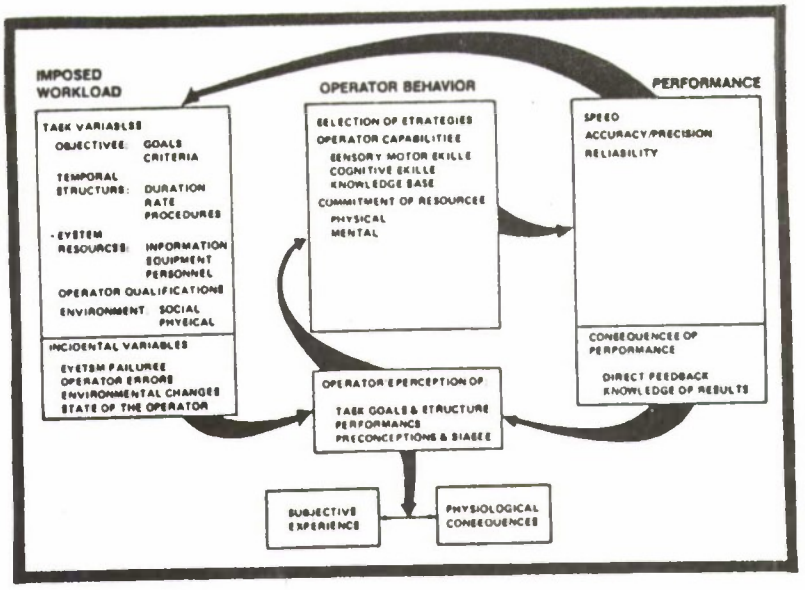
DEVELOP AND VALIDATE TECHNIQUES TO PREDICT AND ASSESS THE EFFECTS OF TASK DEMANDS, ENVIRONMENT, AND TRAINING ON OPERATOR BEHAVIOR, WORKLOAD, AND PERFORMANCE.

APPROACH:

PERFORM GENERIC RESEARCH TO DISCOVER UNDERLYING PRINCIPLES, DEVELOP AND VALIDATE ASSESSMENT TECHNIQUES, AND CREATE PREDICTIVE MODELS.

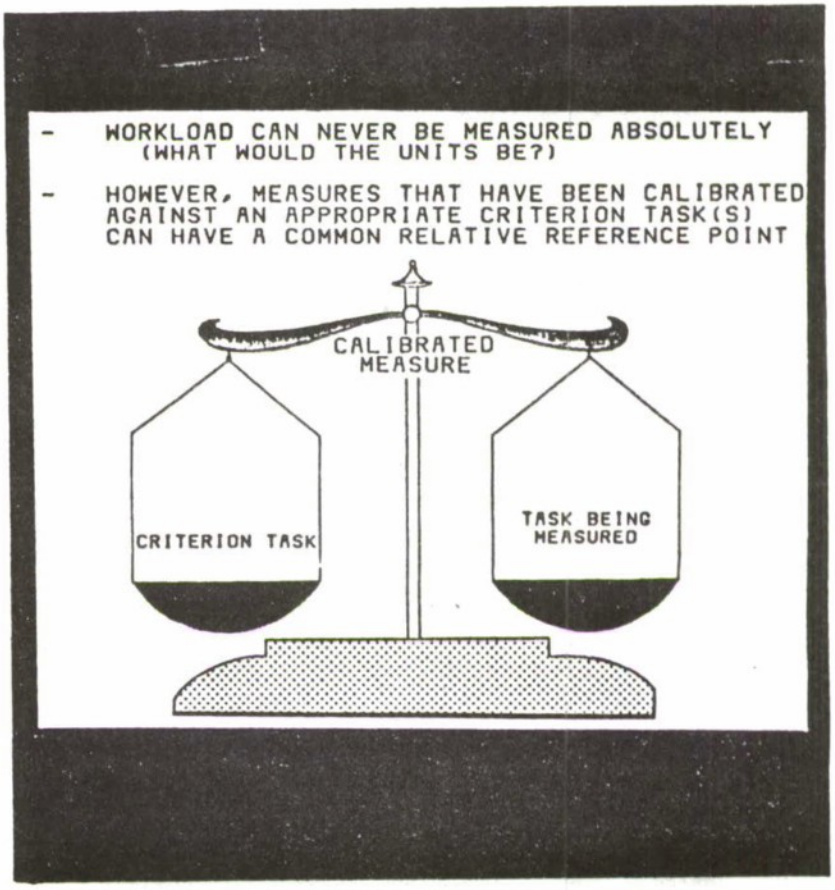
PERFORM VEHICLE-SPECIFIC APPLICATIONS OF GENERIC CONCEPTS AND METHODS TO ADDRESS OPERATIONAL PROBLEMS.



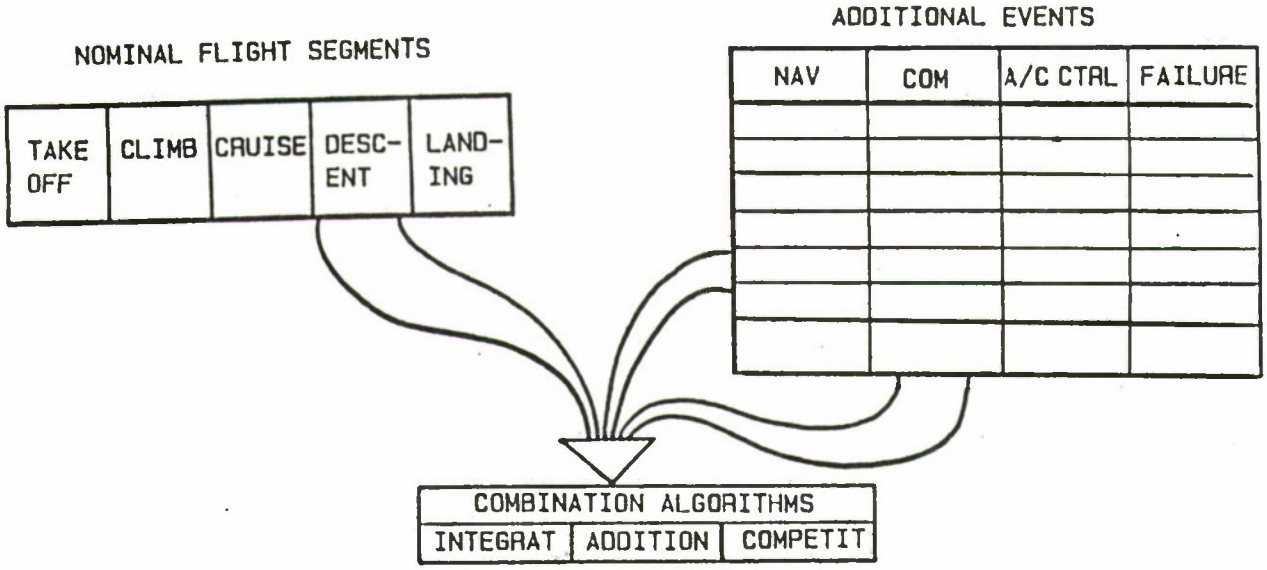


CRITERION TASKS DEVELOPED AT AMES:

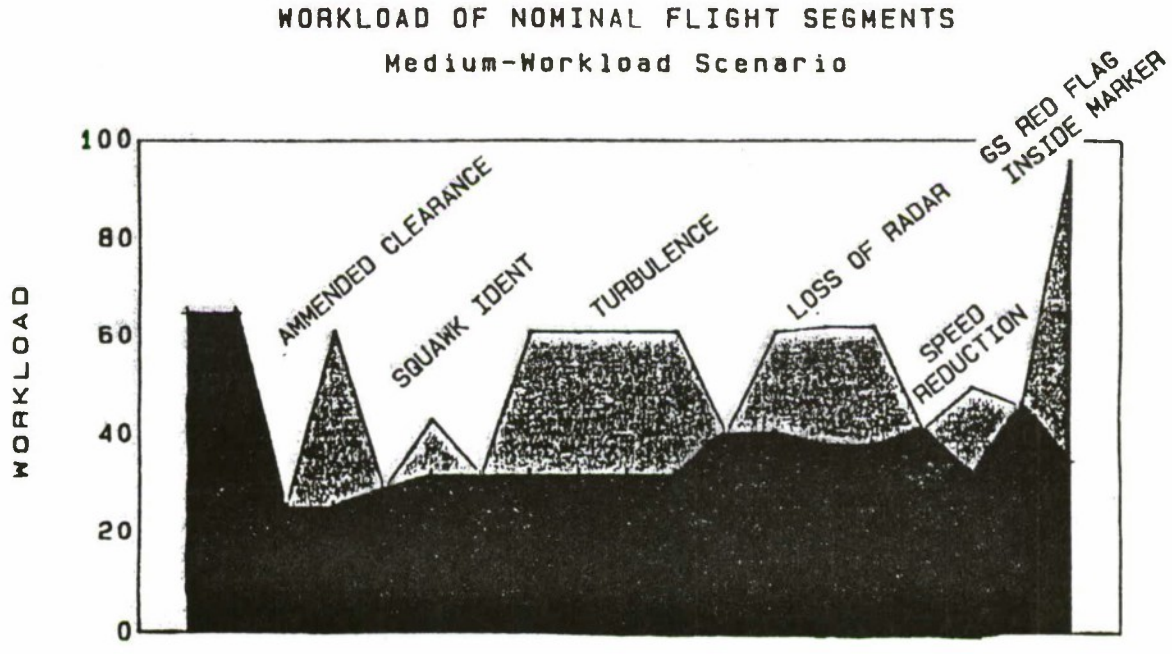
- o FITTSBERG
- o POPCORN
- o MULTI-COCKPIT SIMULATION
- o STANDARD FLIGHT SCENARIO MODEL



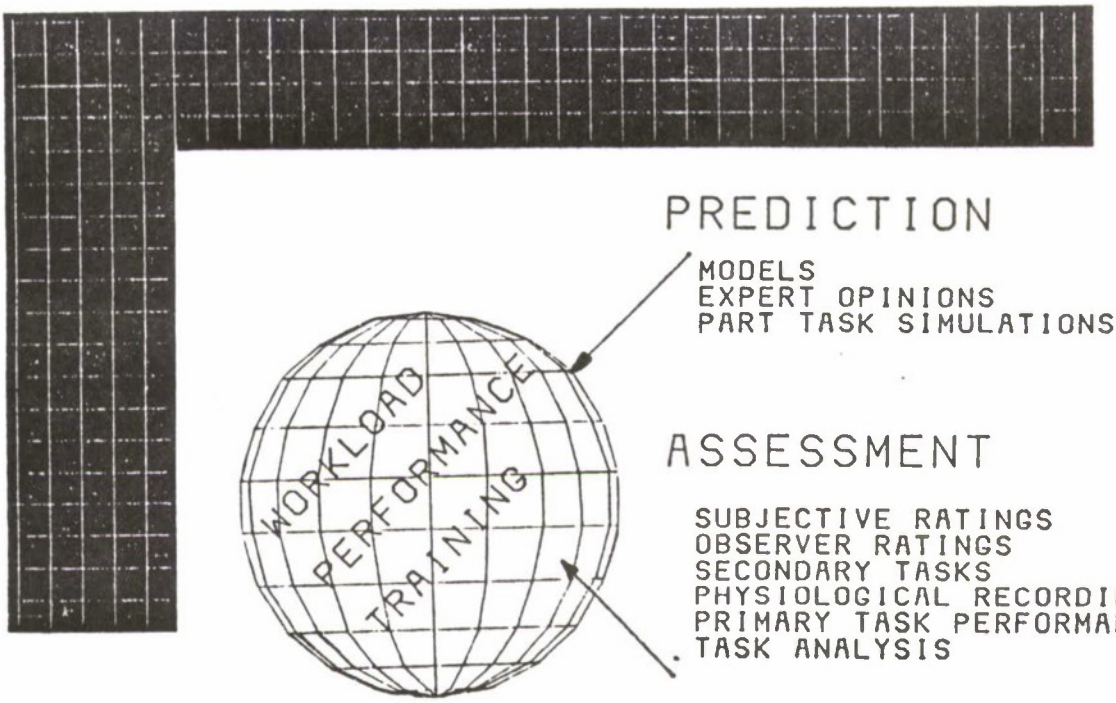
SCENARIO DESIGN PROCEDURE



OUTPUT OF MODEL: PREDICTED WORKLOAD, DURATION



MEASUREMENT TECHNIQUES



COMMUNICATIONS ANALYSIS: MEASURES OF CREW COORDINATION AND DECISION MAKING

OBJECTIVE:

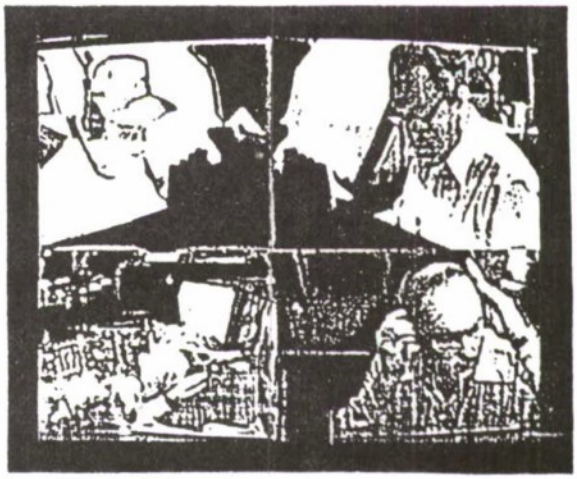
ANALYZE FLIGHT DECK AND ATC COMMUNICATIONS TO ASSESS AIRCREW DYNAMICS COMMUNICATIONS COMPETENCY, AND AIRCRAFT MANAGEMENT

APPROACH:

- o CONDUCT SIMULATIONS IN B-707 SIMULATOR
- o OBTAIN POST-FLIGHT EVALUATIONS BY:
  - (1) CREWMEMBERS
  - (2) EXPERTS IN LINGUISTIC AND SEMANTIC ANALYSIS
  - (3) EXPERTS IN FLIGHT SAFETY

RESULTS:

- o CREWS DIFFERED IN COMMUNICATIONS COMPETENCY AND LEADERSHIP ROLES
- o CREW COORDINATION AFFECTED DECISION MAKING AND AIRCRAFT MANAGEMENT



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SECONDARY TASK MEASURES:

WORKLOAD and PERFORMANCE RESEARCH GROUP

- ASSUMPTIONS:
  - DO NOT INTERFER WITH PRIMARY TASK
  - DO NOT BECOME INTEGRATED WITH PRIMARY TASK
  - OPERATORS CAN ALLOCATE THEIR "RESOURCES" FREELY AND OPTIMALLY
  - SECONDARY TASK PERFORMANCE PREDICTS PRIMARY TASK PERFORMANCE UNDER HIGHER LOAD CONDITIONS BETTER THAN PRIMARY TASK PERFORMANCE DOES
- ISSUES:
  - A SINGLE SECONDARY TASK "YARDSTICK" HAS NOT BEEN FOUND
  - INDIVIDUAL DIFFERENCES IN TIME-SHARING ABILITIES
  - SOME FORMS OF COMPETITION ARE DESIRABLE; SOME ARE NOT
  - DIFFERENTIALLY SENSITIVE TO DIFFERENT PRIMARY TASK LOAD LEVELS
  - ARTIFICIAL (BUT THEORETICALLY SOUND) VS IMBEDDED (TASK-SPECIFIC BUT WITH FACE VALIDITY) TASKS

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SECONDARY TASK MEASURES: EXAMPLES

WORKLOAD and PERFORMANCE RESEARCH GROUP

- MONITORING
- TRACKING
- TIME ESTIMATION
- MEMORY SCAN (STERNBERG)
- MENTAL ARITHMETIC
- ADAPTIVE TECHNIQUES
- CHOICE REACTION TIME

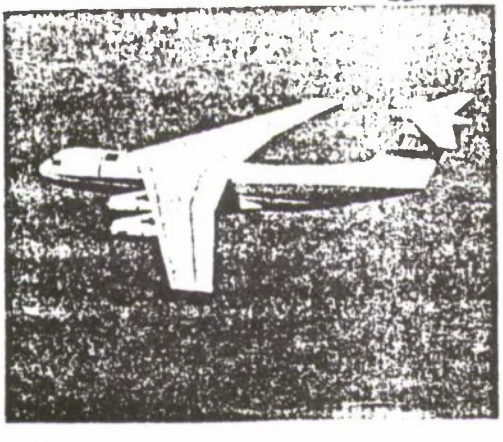
PHYSIOLOGICAL MEASURES: EXAMPLES

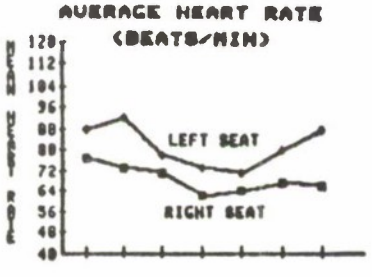
- MEASURES OF MENTAL AND PERCEPTUAL PROCESSING
  - * EVOKED CORTICAL POTENTIALS
  - * EYE POINT OF REGARD
- MEASURES OF EMOTIONAL AND PHYSICAL ACTIVATION
  - * HEART RATE AND VARIABILITY
  - * BLOOD PRESSURE
  - * GALVANIC SKIN RESPONSE
  - * RESPIRATION RATE
  - * MUSCLE TENSION
  - * VOCAL STRESS
  - * PUPIL SIZE

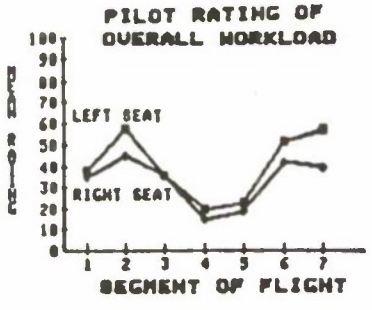
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WORKLOAD and PERFORMANCE RESEARCH GROUP

HEARTRATE AS A WORKLOAD METRIC

NASA C-141 WORKLOAD STUDY







HEARTRATE:

- REFLECTS STRESS, NOT BUSYNESS
- IS MORE SENSITIVE TO STRESS THAN SUBJECTIVE RATINGS

Hart, Hauser & Lester, 1984

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PHYSIOLOGICAL MEASURES: AUDITORY EVOKED POTENTIALS

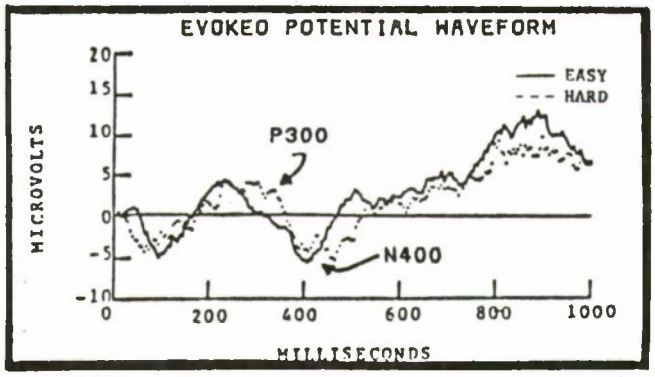
WORKLOAD and PERFORMANCE RESEARCH GROUP

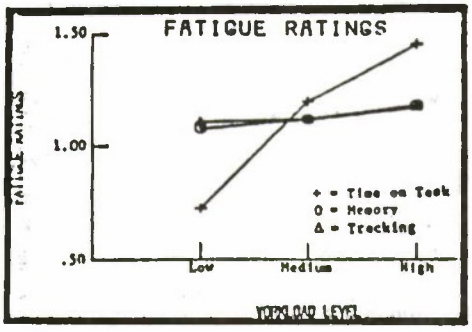
OBJECTIVE: EVALUATE THE VALIDITY AND UTILITY OF AUDITORY EVOKED POTENTIALS COMPONENTS (N400, P300) AS MEASURES OF WORKLOAD AND FATIGUE

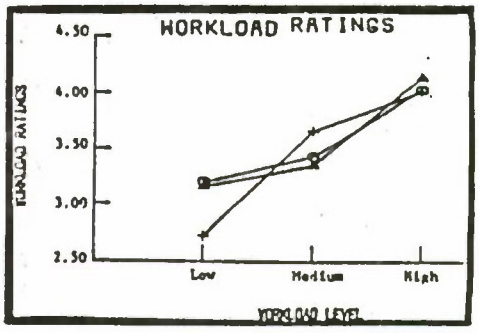
APPROACH: ERPs WERE ELICITED BY PILOT CALL-SIGNS PRESENTED AUDITORIALLY DURING CONCURRENT TRACKING

RESULTS: A SIGNIFICANT NUMBER OF SUBJECTS EXHIBITED CORRELATIONS BETWEEN:

- WORKLOAD RATINGS AND P300 AMPL
- WORKLOAD RATINGS AND N400 AMPL
- FATIGUE AND P300 AMPL







Biferno, 1985

NASA
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SUBJECTIVE RATINGS: ISSUES

WORKLOAD and PERFORMANCE RESEARCH GROUP

- PROVIDE SIGNIFICANT SOURCE OF INFORMATION
- MAY TAP THE ESSENCE OF MENTAL WORKLOAD
- REFLECT SUBSET OF INFORMATION AVAILABLE DURING TASK PERFORMANCE
  - RESULTS OF INFORMATION PROCESSING
  - MEMORIES
  - OVERT BEHAVIOR
  - FEELINGS
- INDIVIDUAL DIFFERENCES IN DEFINITION AND AND EXPERIENCE
- NO MENTAL REFERENCE SCALE FOR "WORKLOAD"
- BEST TO COMPARE SHARED QUALITIES AND SIMILAR ACTIVITIES
- CALIBRATION OF RATERS
- TIMING
  - ON-LINE vs RETROSPECTIVE
  - PRIMACY/RECENCY OR ODDBALL EFFECTS
- PSYCHOMETRIC CONSIDERATIONS
  - EQUALITY OF INTERVALS
  - NO "ZERO" POINT OR "MAXIMUM"

DEVELOPMENT OF A SUBJECTIVE RATING SCALE FOR WORKLOAD

OBJECTIVE: EMPIRICALLY DETERMINE THE NECESSARY TASK, BEHAVIOR, PERFORMANCE, AND SUBJECT-RELATED SUBSCALES, THE RULES BY WHICH THEY MAY BE COMBINED TO ESTIMATE OVERALL WORKLOAD, AND THE IMPLEMENTATION AND DESIGN OF THE SCALES.

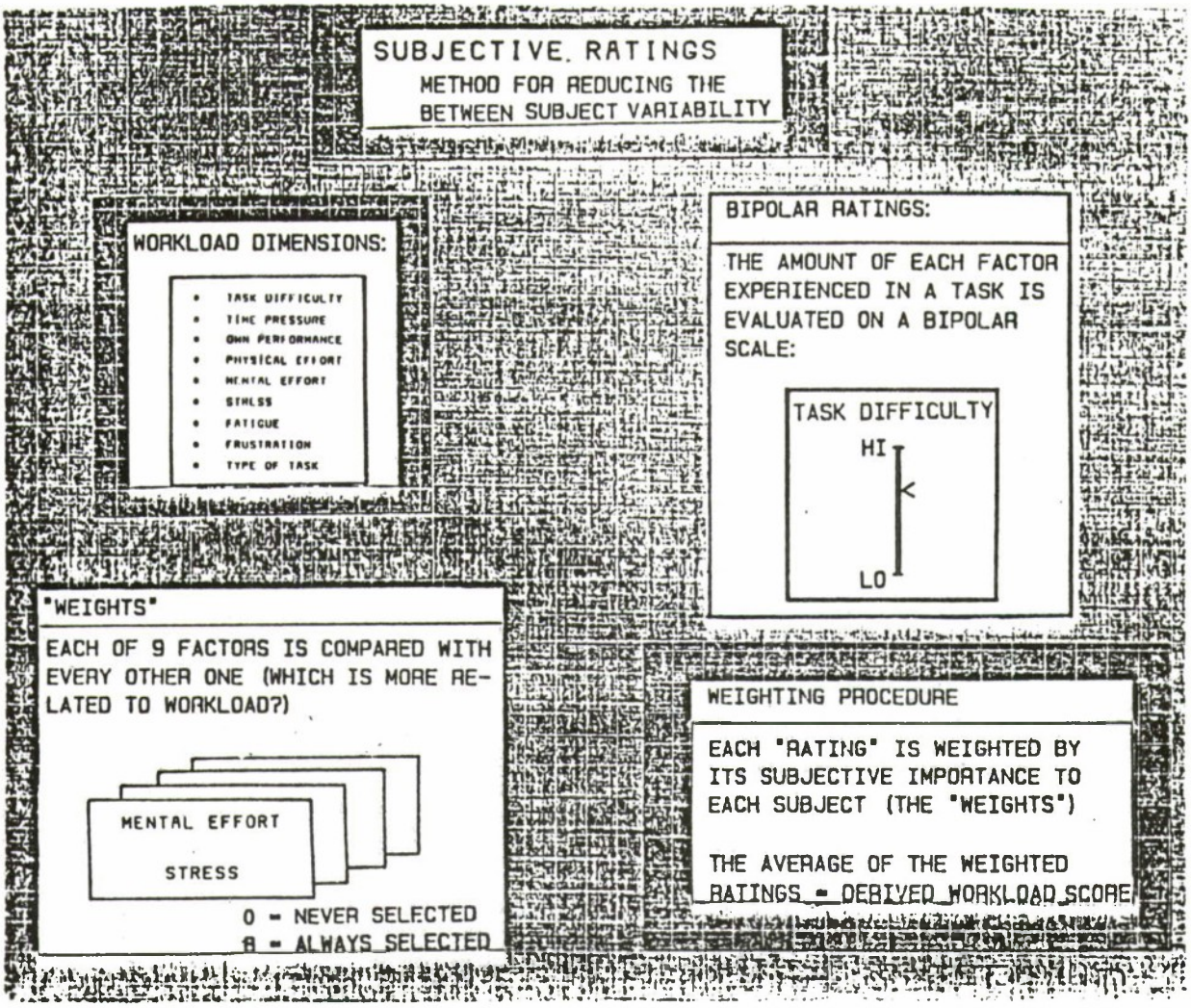
APPROACH: OBTAIN INFORMATION ABOUT THE IMPORTANCE, MAGNITUDE, AND SENSITIVITY OF 10 CANDIDATE FACTORS IN 15 EXPERIMENTS THAT INCLUDED SIMPLE MANUAL CONTROL, DECISION MAKING AND INFORMATION PROCESSING, SUPERVISORY CONTROL, AND SIMULATED FLIGHT.

RESULTS:

1. SOURCES AS WELL AS MAGNITUDES OF WORKLOAD DIFFERED WITHIN AND BETWEEN EXPERIMENTAL TASKS
2. INDIVIDUAL WORKLOAD DEFINITIONS VARIED WIDELY
3. SIX FACTORS WERE SELECTED AS THE OPTIMAL WORKLOAD SUBSCALES: MENTAL, PHYSICAL, & TEMPORAL DEMANDS, PERFORMANCE, EFFORT & FRUSTRATION
4. 20 SCALE INTERVALS LIMITED BY BIPOLAR ANCHORS PROVIDE A PRACTICAL AND SUFFICIENTLY SENSITIVE MECHANISM TO OBTAIN SUBSCALE MAGNITUDE RATINGS
5. A COMPARISON AMONG THE SIX SUBSCALES TO SPECIFY THEIR IMPORTANCE AS SOURCES OF WORKLOAD PROVIDE IMPORTANCE WEIGHTS FOR EACH SUBJECT
6. THE AVERAGE OF THE MAGNITUDES RATINGS FOR THE SIX SUBSCALES, EACH WEIGHTED BY THE IMORTANCE ATTACHED TO THEM AS A WORKLOAD-SOURCE FOR THAT TASK, PROVIDES A STABLE AND SENSITIVE WORKLOAD INDEX.

THE TYPES OF EXPERIMENTAL TASKS INCLUDED IN THE WORKLOAD RATING SCALE DEVELOPMENT EFFORT

- SIMPLE, COGNITIVELY-LOADING TASKS
  CHOICE REACTION TIME, MEMORY SEARCH, MENTAL ARITHMETIC, MENTAL ROTATION, PATTERN MATCH
- SIMPLE, MANUALLY-LOADING TASKS
  ONE AND TWO AXIS TRACKING
- CONCURRENT, INDEPENDENT DUAL-TASKS
  TRACKING + MEMORY SEARCH, MENTAL ROTATION
- SERIAL, INTEGRATED "FITTSBERG" TASKS
  TARGET ACQUISITION + MEMORY SEARCH, MENTAL ARITHMETIC, RHYMING, PATTERN MATCH, PREDICTION, TIME ESTIMATION
- COMPLEX SUPERVISORY CONTROL SIMULATIONS ("POPCORN")
- PART-TASK AND FULL-MISSION AIRCRAFT SIMULATIONS



SUBSCALES SELECTED FOR NASA WORKLOAD RATING SCALE

TASK RELATED:	o MENTAL DEMANDS	(MD)
	o PHYSICAL DEMANDS	(PD)
	o TEMPORAL DEMANDS	(TD)
RESPONSE-RELATED:	o EFFORT EXPENDED	(EF)
	o PERFORMANCE QUALITY	(QP)
	o FRUSTRATION LEVEL	(FR)

APPENDIX A

EXAMPLE: COMPARE WORKLOAD OF TWO TASKS THAT REQUIRE A SERIES OF DISCRETE RESPONSES. THE PRIMARY DIFFICULTY MANIPULATION IS THE INTER-STIMULUS INTERVAL (ISI)- (TASK 1 = 500 MSEC. TASK 2 = 300 MSEC)

PAIR-WISE COMPARISONS OF FACTORS:

INSTRUCTIONS: SELECT THE MEMBER OF EACH PAIR THAT PROVIDED THE MOST SIGNIFICANT SOURCE OF WORKLOAD VARIATION IN THESE TASKS.

PD / MD	TP / PD	TP / FR
TP / MD	OP / PD	TP / EF
OP / MD	FR / PD	OP / FR
FR / MD	EF / PD	OP / EF
EF / MD	TP / OP	EF / FR

TALLY OF IMPORTANCE SELECTIONS:

MD III	= 3
PD	= 0
TP IIIII	= 5
OP I	= 1
FR III	= 3
EF III	= 3
SUM	= 15

RATING SCALES:

INSTRUCTIONS: PLACE A MARK ON EACH SCALE THAT REPRESENTS THE MAGNITUDE OF EACH FACTOR IN THE TASK YOU JUST PERFORMED.

RATINGS FOR TASK 1:

				RATING		WEIGHT		PRODUCT
MD	LOW	I_____I	HIGH	30	*	3	=	90
PD	LOW	I_____I	HIGH	15	*	0	=	0
TD	LOW	I_____I	HIGH	60	*	5	=	150
OP	EXCL	I_____I	POOR	40	*	1	=	40
FR	LOW	I_____I	HIGH	30	*	3	=	90
EF	LOW	I_____I	HIGH	40	*	3	=	120
						SUM	=	490
						WEIGHTS (TOTAL)	=	15
						MEAN WWL SCORE	=	32

RATINGS FOR TASK 2:

				RATING		WEIGHT		PRODUCT
MD	LOW	I_____I	HIGH	30	*	3	=	90
PD	LOW	I_____I	HIGH	25	*	0	=	0
TD	LOW	I_____I	HIGH	70	*	5	=	350
OP	EXCL	I_____I	POOR	50	*	1	=	50
FR	LOW	I_____I	HIGH	50	*	3	=	150
EF	LOW	I_____I	HIGH	30	*	3	=	90
						SUM	=	730
						WEIGHTS (TOTAL)	=	15
						MEAN WWL SCORE	=	49

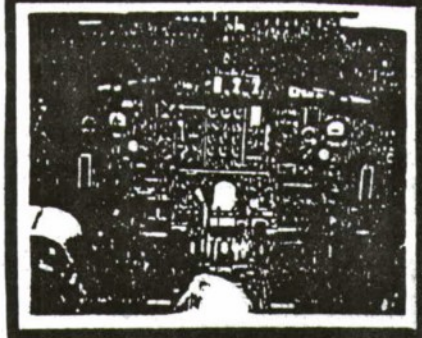
RESULTS: SUBSCALES PINPOINT SPECIFIC SOURCE OF WORKLOAD VARIATION BETWEEN TAKS (TP). THE WWL SCORE REFLECTS THE IMPORTANCE OF THIS AND OTHER FACTORS AS WORKLOAD-DRIVERS AND THEIR SUBJECTIVE MAGNITUDE IN EACH TASK.

VALIDATION OF NASA WORKLOAD ASSESSMENT MEASUREMENT BATTERY

OBJECTIVE: DETERMINE THE SENSITIVITY AND OPERATIONAL VALIDITY OF THE WORKLOAD MEASURES DEVELOPED AT NASA-AMES

APPROACH: CONSTRUCT SCENARIOS WITH WORKLOAD PREDICTIVE MODEL
PERFORM FLIGHTS IN B-727 SIMULATOR AND SH-3 HELICOPTER
COMPARE MODEL PREDICTIONS TO EMPIRICAL RESULTS

MEASURES: PERFORMANCE (COMMUNICATIONS, ERRORS, CREW COORDINATION, CONTROL VARIABILITY, SECONDARY TASKS)
PHYSIOLOGICAL (HEART RATE/VARIABILITY, EYE BLINK RATE/TIMING, SCAN PATTERN, AUDITORY EVOKED CORTICAL POTENTIALS)
SUBJECTIVE (NASA MULTI-DIMENSIONAL SCALE, REFERENCE TASK COMPARISON, MODIFIED COOPER-HARPER SCALE)



MVSAF 727 COCKPIT



SH-3 HELICOPTER

SELECTING APPROPRIATE WORKLOAD ASSESSMENT MEASURES
(NASA "EXPERT" SYSTEM)

FORMALIZE THE FOCUS OF A WORKLOAD QUESTION:

MISSION REQUIREMENTS?
\+ DESIGN ALTERNATIVES?
SYSTEM PERFORMANCE?
ASSIGNMENT OF DUTIES?
(MAN OR MACHINE?)
CREW COMPLEMENT?
TRAINING REQUIREMENTS?
CREW SATISFACTION, HEALTH?

DETAILED DESCRIPTIONS OF CANDIDATE MEASURES (REFERENCES)

INSTRUCTIONS FOR APPLICATION AND ANALYSIS

SPECIFY RESEARCH ENVIRONMENT:

LABORATORY
* SIMULATION
INFLIGHT
UNDER DEVELOPMENT

APPROPRIATE MEASURES GIVEN THE QUESTION (*) AND THE ENVIRONMENT (+):

SUBJECTIVE RATINGS
SECONDARY TASK PERFORMANCE
PRIMARY TASK PERFORMANCE
VISUAL SCAN PATTERN

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5 November 1985

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ATTACHMENT M.1

USER-COMPUTER INTERACTION

-- ATTENDEE LIST

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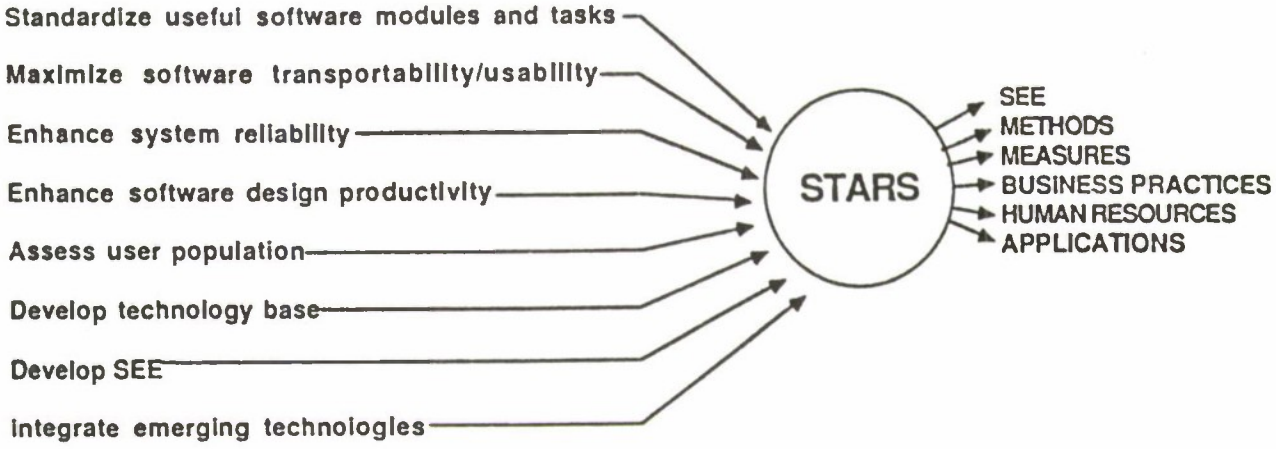
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ATTACHMENT M.2

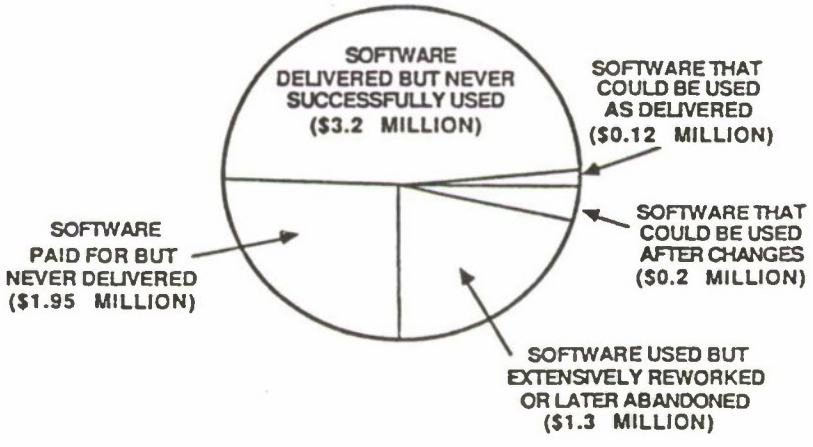
STARS: SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS

DOD MCCR NEEDS



STARS

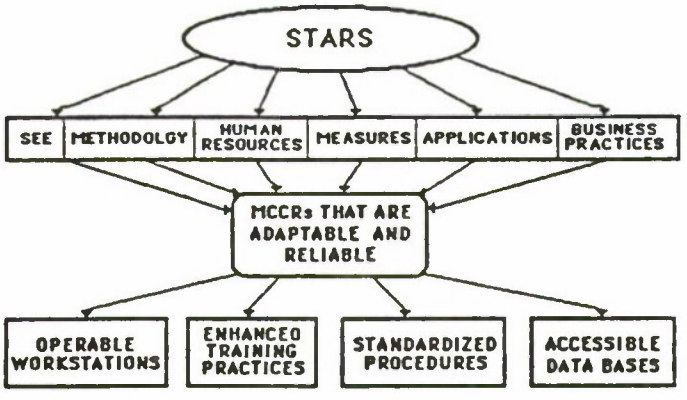
A SYSTEMATIC RESPONSE TO SYSTEMIC CRISIS



RESULTS OF AN AUDIT OF NINE DOD SOFTWARE DEVELOPMENT EFFORTS TOTALING $6.8 MILLION
(SOURCE: COMPTROLLER GENERAL REPORT TO CONGRESS)

STARS MISSION

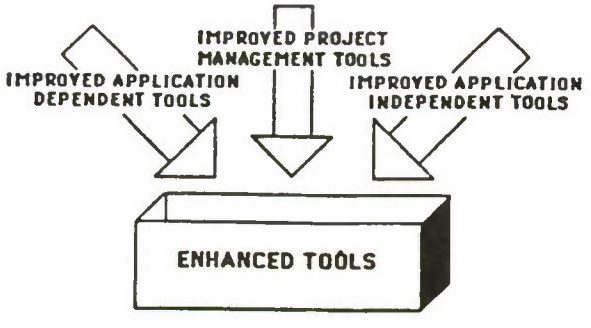
TO ENHANCE SOFTWARE USABILITY, MAINTAINABILITY AND PRODUCTIVITY BY IMPROVING THE STATE OF PRACTICE IN THE ACQUISITION, MANAGEMENT, DEVELOPMENT AND SUPPORT OF SOFTWARE FOR MISSION-CRITICAL COMPUTER RESOURCES (MCCRs).



STARS OBJECTIVES

1. ENHANCE THE POWER OF TOOLS BY:

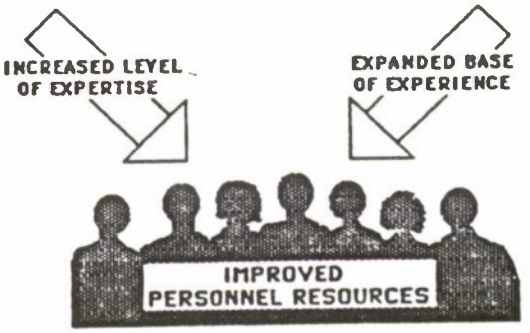
- IMPROVING PROJECT MANAGEMENT TOOLS
- IMPROVING APPLICATION-INDEPENDENT TECHNICAL TOOLS
- IMPROVING APPLICATION-SPECIFIC TECHNICAL TOOLS



STARS OBJECTIVES

2. IMPROVE PERSONNEL RESOURCES BY:

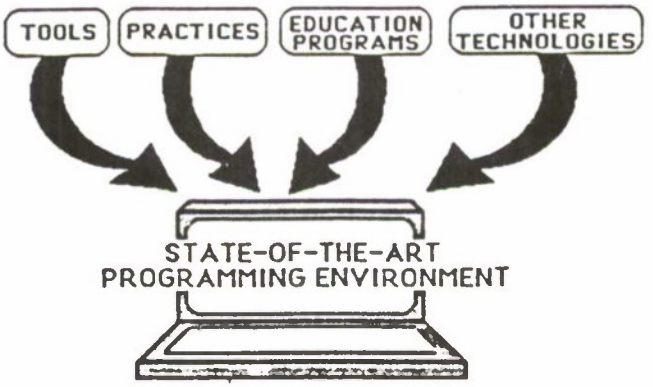
- INCREASING THE LEVEL OF EXPERTISE
- EXPANDING THE BASE OF EXPERTISE AVAILABLE TO DoD



STARS STRATEGY

A THREE-STAGE EVOLUTIONARY APPROACH:

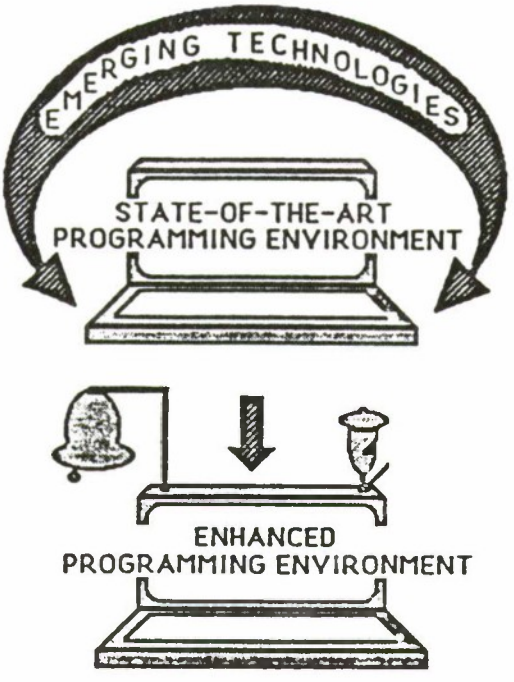
STAGE 1 - CONSOLIDATION of demonstrated tools, techniques, practices, educational programs, and other technologies into a state-of-the-art programming environment.



STARS STRATEGY

A THREE-STAGE EVOLUTIONARY APPROACH:

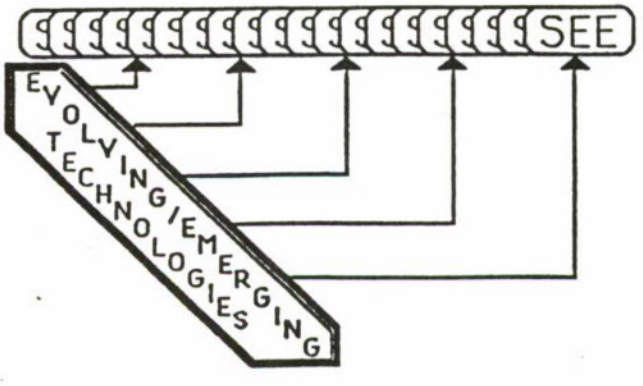
STAGE 2 - ENHANCEMENT of the Stage 1 environment through application/creation of emerging technologies



STARS STRATEGY

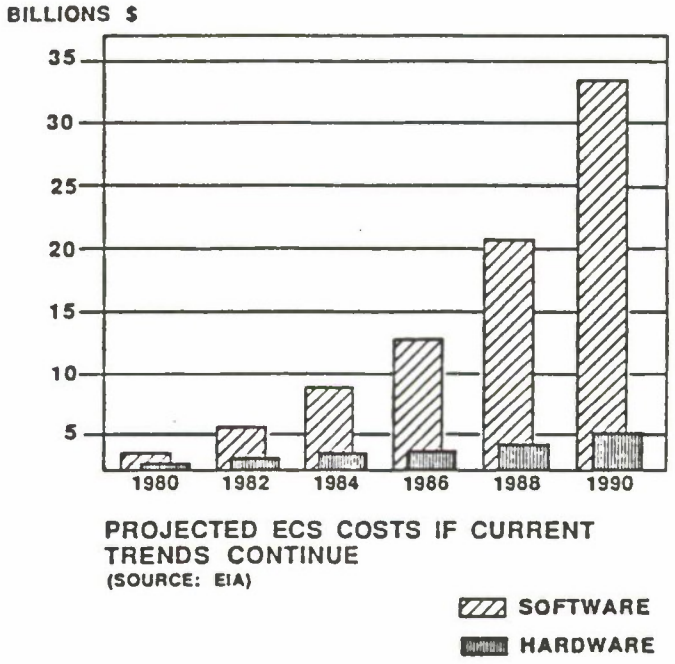
A THREE-STAGE EVOLUTIONARY APPROACH:

STAGE 3 - TRANSITION to a steadily evolving environment



SEE

THE SOFTWARE CRISIS
-COST-



PROJECTED ECS COSTS IF CURRENT TRENDS CONTINUE
(SOURCE: EIA)

SEE

THE SOFTWARE CRISIS
- QUALITY -

UNRESPONSIVE - Does not meet user needs

UNRELIABLE - Does not ensure error-free performance

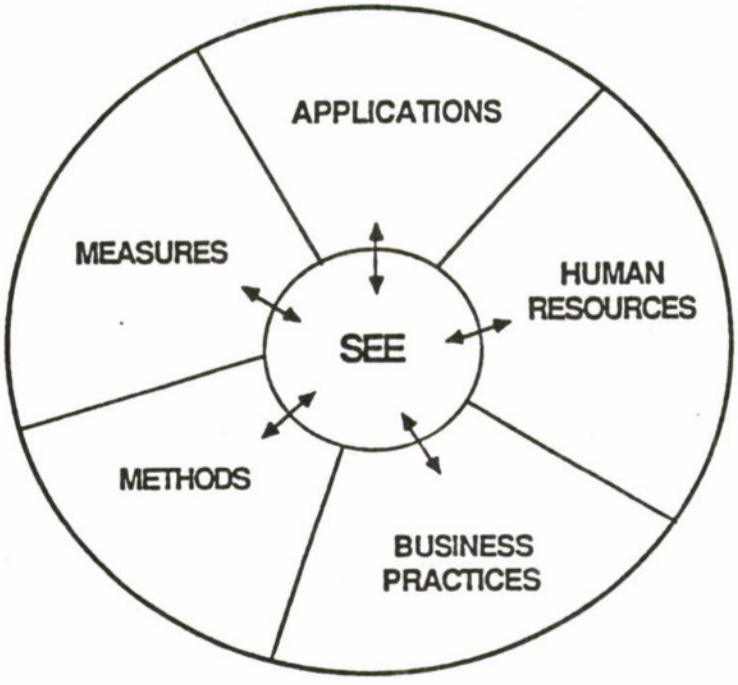
COSTLY - Frequently over-budget; often excessive

UNMODIFIABLE - Maintenance is complex, costly and error-prone

UNTIMELY - Frequently late; often less capable than advertised

NON-PORTABLE - Software from one system will not run on another system - even when functions are similar

INEFFICIENT - Development efforts do not optimize utilization of resources (processing time, memory space)



THE SEE MISSION

Support of MCCR* software engineering through all phases of the software life cycle

Direct, computer-based support of the life cycle functions themselves, including support for the programming languages in which the MCCR sotware is encoded

Management of MCCR software products

Support of the users who develop, support, reuse, manage and control MCCR software

*MCCR = Mission Critical Computer Resource

SEE EMPHASIS

STANDARDIZATION of all interfaces, tools, methods, measures and business practices

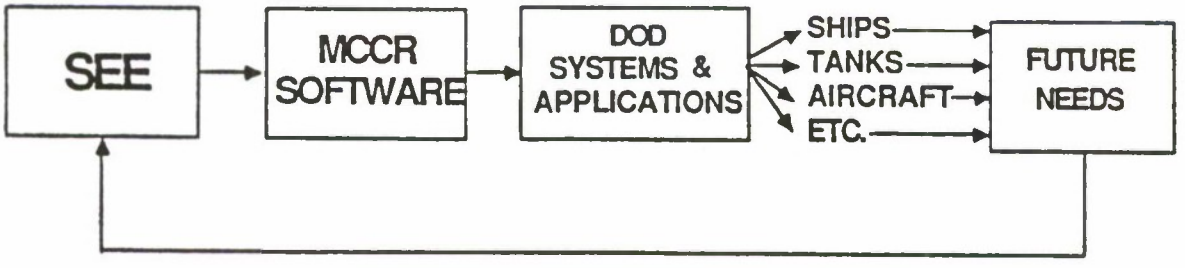
COMPATIBILITY across modules

TRANSPORTABILITY between systems

INTEGRATION of all human, machine and software elements

SEE

ITERATIVE DESIGN



HUMAN ENGINEERING FOR STARS
1985 EFFORT

TASK 1
STARS Human Engineering Program Plan

Objective: To develop an overall STARS human engineering program plan that integrates the various STARS elements

Status: Draft program plan submitted for review and comment

HUMAN ENGINEERING FOR STARS
1985 EFFORT

TASK 2
STARS Program Support

Objective: To support the STARS program in terms of planning technology development, technical assessments and surveys, and human factors reviews of program products

Status: Technology plan in preparation for developing user interface requirements for STARS products employing emerging technology. Major emphasis is on functional allocation in automated systems. Scheduled delivery by 31 October 1985.

HUMAN ENGINEERING FOR STARS
1985 EFFORT

TASK 3
Planning and Coordination of Symposia and Workshops

Objective: To plan, coordinate, conduct and disseminate the results of STARS human engineering symposia and workshops.

Status: Agenda for strategy/coordination workshop prepared and submitted for review and comment.

HUMAN ENGINEERING FOR STARS
1985 EFFORT

TASK 4
Scaling of Users, Systems and Environments

Objective: To review the state of knowledge and develop a plan for scaling of system users, systems and environments.

Status: Preliminary definition of scaling objectives and applications in preparation. Scheduled for delivery by 31 October 1985.

Literature search initiated on scaling methods and applications.

TASK 4
Scaling of Users, Systems and Environments
ACTIVITIES AND PRODUCTS

ACTIVITIES: 1. Identify scaling objectives and applications for STARS (in progress)

2. Review the state-of-knowledge for user, system and environment scaling in computer-based systems

3. Develop methods and identify criteria for user, system and environment scaling for STARS

4. Integrate scaling methods and criteria into STARS-SEE workstations for program managers, systems analysts and human engineers.

PRODUCTS: 1. A description of the state-of-knowledge for user, system and environment scaling in computer-based systems

2. A detailed specification describing the objectives and application of scaling methods and criteria for complexity, workload and information flow in computer-based systems.

HUMAN ENGINEERING FOR STARS
1985 EFFORT

TASK 5
User-Workstation Interface Design Requirements

Objective: To review the state of knowledge and develop an R&D plan for determining STARS user-workstation interface requirements

Status: Preliminary list of user functions and activities prepared and submitted for review and comment.

Literature search initiated on workstation design for APSE (Ada Programming Support Environment).

Draft SEE user questionnaire prepared and submitted for review and comment.

TASK 5
User-Workstation Interface Design Requirements

ACTIVITIES AND PRODUCTS

ACTIVITIES: 1. Review the state-of-knowledge for user-workstation interface design

2. Define range of functions and activities of each class of STARS-SEE users, focusing on project managers, system analysts, programmers, and human engineers

3. Identify the number of unique functions and activities of STARS-SEE users and describe their associated requirements and interfaces

4. Prepare a detailed specification for user-workstation interface requirements organized by user class, function and activity.

PRODUCTS: 1. A description of the state-of-knowledge for user-workstation interface design requirements

2. A detailed specification describing the objectives and application of user-workstation design requirements for each user class, function and activity.

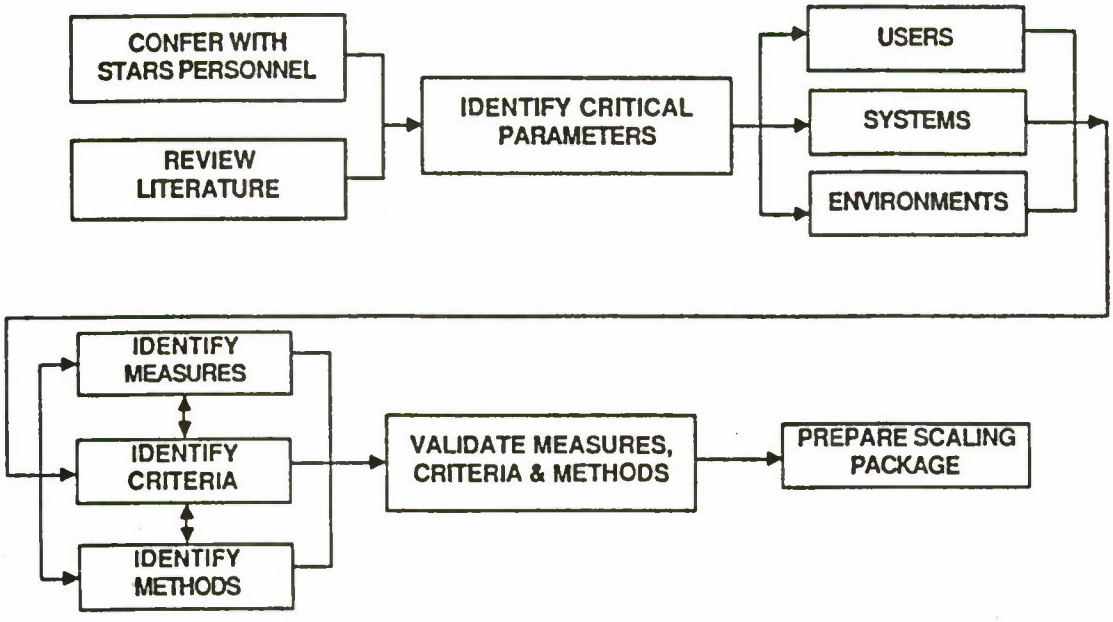
ATTACHMENT M.3

USER, SYSTEM AND ENVIRONMENT SCALING

USER, SYSTEM & ENVIRONMENT SCALING

OBJECTIVE: To develop and validate methods, measures and criteria for scaling user characteristics, system usability and environmental complexity.

USER, SYSTEM & ENVIRONMENT SCALING TASK FLOW



CANDIDATE SCALING PARAMETERS

USERS

- Experience
- Skill/Knowledge Levels
- Aptitudes

SYSTEMS

- Operational Complexity
- Usability
- Workload
- Error Tolerance

ENVIRONMENTS

- Operational Complexity
- Workload
- Error Tolerance

CANDIDATE SCALING MEASURES

USERS

EXPERIENCE

- Formal Training
- OJT
- Systems (number, variety)

SKILL/KNOWLEDGE LEVELS

- Proficiency Scores
- Supervisor ratings
- Special Tests

APTITUDES

- Traditional (e.g., mechanical, clerical, etc)
- Innovative (e.g., multi-dimensional spatial)

CANDIDATE SCALING MEASURES

SYSTEMS

OPERATIONAL COMPLEXITY

- Number of decisions
- Complexity of decisions
- Criticality of decisions

USABILITY

- Availability of information
- Quality of information

WORKLOAD

- Rate of decision making

ERROR TOLERANCE

- Precision/accuracy requirements
- Error detection/recovery procedures

CANDIDATE SCALING MEASURES
ENVIRONMENTS

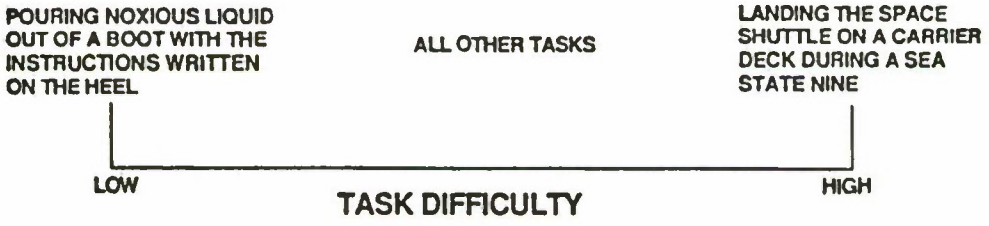
WORKLOAD

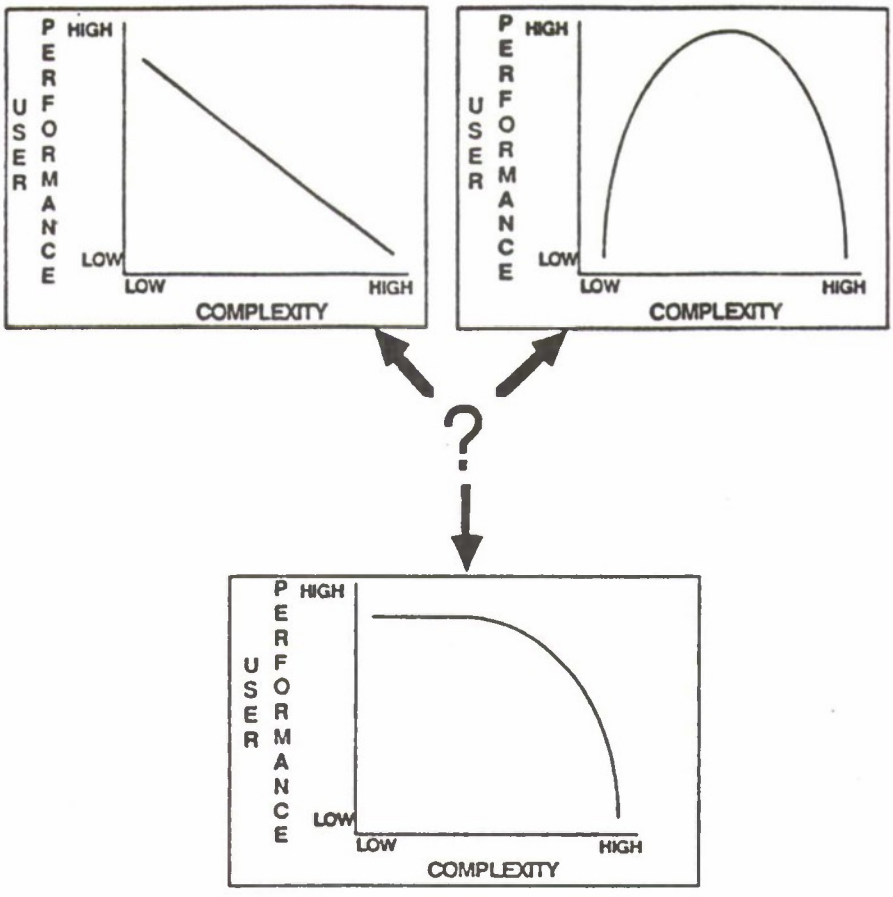
- Rate of decision making
- Criticality of decisions

ERROR TOLERANCE

- Threat environment
- Precision/accuracy requirements
- Error detection/recovery procedures

KIRKPATRICK'S CONTINUUM OF TASK DIFFICULTY





RELATIONSHIP OF SYSTEM/ENVIRONMENT COMPLEXITY TO USER PERFORMANCE

CANDIDATE SCALING TECHNIQUES

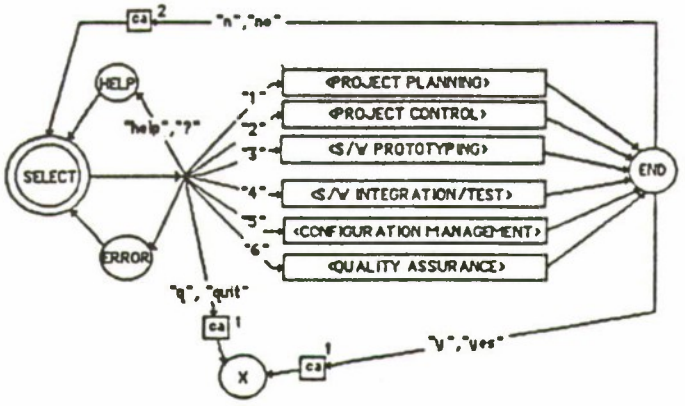
SYSTEM COMPLEXITY-TASK DIFFICULTY

DIRECT MEASUREMENT-State Transition Diagrams

- NUMBER OF DECISION POINTS (Nodes)
  - Per Task
  - Per Screen
  - Per Unit Time
- COMPLEXITY OF DECISION POINTS (Nodes)
  - Availability of information
  - Quality of information
- NUMBER OF INPUT REQUIREMENTS (Arcs)
  - Per Task
  - Per Unit Time
- CONSISTENCY OF INPUT REQUIREMENTS (Arcs)
  - Within tasks/modules
  - Across tasks/modules

EXAMPLE STATE TRANSITION DIAGRAM

PROGRAM MANAGER'S "TOOL SCREEN"



Actions (É)
1 call shutdown
2 call startup

Diagram main entry=select, exit="n", "no"

Message header= "TOOLS MENU"

Message lastline = "Press "Q" to quit, or
"M" to return to main menu"

Node SELECT
"Please Choose:"
"1. Project Planning"
"2. Project Control"
"3. Software Prototyping"
"4. Software Integration and Testing"
"5. Configuration Management"
"6. Quality Assurance"
"H(elp): Information on use of program"
"Q(uit): End session"
"Your choice:__"

Node HELP
"For more information about a command,
enter the command number, "
"followed by a ? and press 'return' "
"or type "help" or "?" while in the command mode."

Node ERROR
bell
"Please enter the approriate number (1-6) to select a
command,"
"Or enter "help" or "?" for help, or "quit" to end session"

Node END
"If you are finished and would like to end this session, enter
"Yes'""
"To return to the main menu, enter "No'""
"End session?__"

Node X
clear screen
return to OS

CANDIDATE SCALING TECHNIQUES
SYSTEM COMPLEXITY-TASK DIFFICULTY

INDIRECT MEASUREMENT - Magnitude Estimation

APPROACH:

1. Develop Task "simulators" with adjustable level of difficulty for generic tasks (pattern recognition, discrimination, fine motor, etc.)

2. Develop continuum of empirical error probabilities for varying levels of difficulty for each task

3. Have experienced operators adjust simulators to equal perceived difficulty for real-world tasks for different systems and operating environments

4. Extrapolate error probabilities/task difficulty for real-world tasks, systems ans operating environments

5. Develop compendium of error probabilities for each task type, system and operating environment

ATTACHMENT M.4

USER-WORKSTATION INTERFACE REQUIREMENETS

HUMAN ENGINEERING FOR STARS

MISSION: To develop and validate human engineering principles, methods and criteria that will enhance productivity throughout the life cycle of mission-critical computer resources.

KEY PLAYERS:

UCI WORKING GROUP

STARS HUMAN ENGINEERING STANDARDIZATION GROUP

HUMAN ENGINEERING FOR STARS

OBJECTIVES:

1. TO MAXIMIZE PRODUCTIVITY OF EMERGING ADA PROGRAMMING SUPPORT ENVIRONMENTS (APSEs) BY FOCUSING ON THE REQUIREMENTS OF THE SOFTWARE PROFESSIONAL.

2. TO EXPAND THE EXPERIENCE BASE THROUGH THE APPLICATION OF HUMAN ENGINEERING TECHNOLOGY TO ACTUAL DEVELOPMENT PROJECTS.

3. TO EXPAND THE TECHNOLOGY BASE BY SUPPORTING CONTINUED DEVELOPMENT OF HUMAN ENGINEERING KNOWLEDGE, METHODS AND TOOLS.

HUMAN ENGINEERING FOR STARS
STRATEGY:

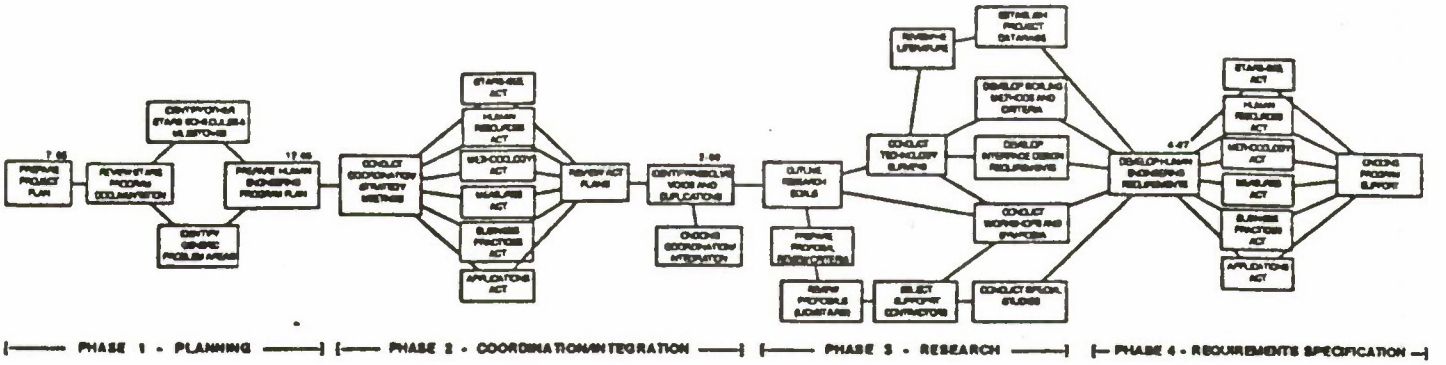
1. SUPPORT THE SYSTEMATIC APPLICATION OF CURRENT HUMAN ENGINEERING KNOWLEDGE TO DESIGN THE USER INTERFACE FOR THE AUTOMATED PROGRAMMING SUPPORT ENVIRONMENT.

2. SUPPORT THE SYSTEMATIC APPLICATION OF CURRENT HUMAN ENGINEERING KNOWLEDGE TO CONDUCT EXPERIMENTS TO ESTABLISH AND TEST BASIC PRINCIPLES AND MODELS OF HUMAN-COMPUTER INTERACTION AND PROBLEM SOLVING.

3. SUPPORT THE SYSTEMATIC APPLICATION OF CURRENT HUMAN ENGINEERING KNOWLEDGE TO PROVIDE FOR DEVELOPMENT AND CONTINUED ENHANCEMENT OF A GENERAL HUMAN ENGINEERING METHODOLOGY AND ASSOCIATED SUPPORT TOOLS.

4. SUPPORT THE SYSTEMATIC APPLICATION OF CURRENT HUMAN ENGINEERING KNOWLEDGE TO IDENTIFY MEASURES TO ASSESS PROGRESS.

HUMAN ENGINEERING FOR STARS



STARS HUMAN ENGINEERING PROGRAM PLAN

OBJECTIVE: To review the state-of-knowledge and conduct research, as necessary, to achieve the objectives of the human engineering Program Plan

ACTIVITIES: 1. Outline research goals

2. Identify and select support contractors

3. Conduct technology surveys

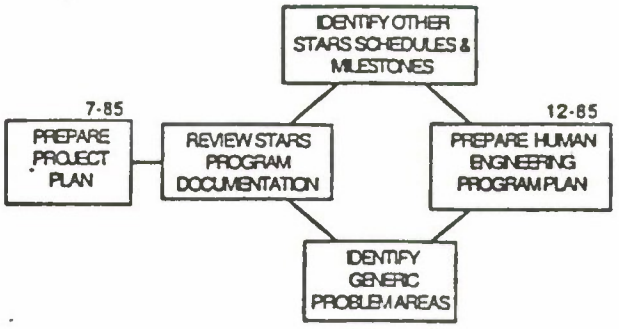
4. Conduct workshops and symposia

5. Conduct special studies

PRODUCTS: 1. Near- and long-term research goals

2. Reports on the state-of-knowledge for selected topic areas

3. Results of workshops, symposia, technology surveys and special studies



[---------- PHASE 1 - PLANNING ----------]

OBJECTIVE: To develop an overall STARS human engineering program plan that integrates the various STARS ACT activities.

ACTIVITIES: 1. Prepare project plan

2. Review STARS Program documentation

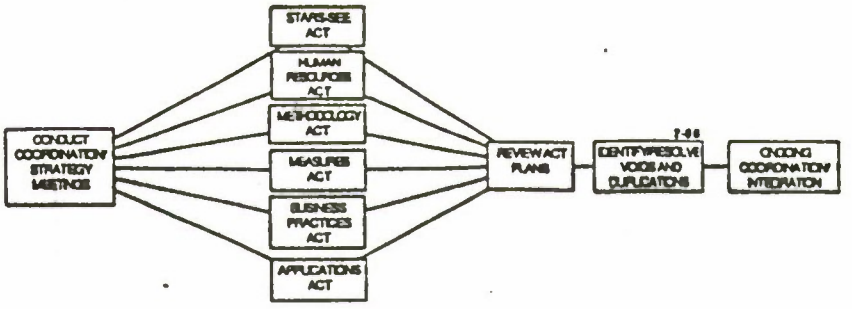
3. Prepare human engineering Program Plan

PRODUCT: A detailed Program Plan specifying critical human engineering objectives, activites and products associated with each major STARS milestone.

Draft Program Plan focuses on six areas:

1. Coordination and integration of STARS activities
2. User-computer interface requirements for SEE workstations
3. Design of training systems and devices for SEE
4. Human factors in software system acquisition
5. Methods and measures for user, system and environment scaling
6. Methods and procedures for a standard human engineering process for software development.

HUMAN ENGINEERING FOR STARS



[———— PHASE 2 - COORDINATION/INTEGRATION ————]

OBJECTIVE: To assist STARS Area Coordinating Teams (ACTs) in coordinating and integrating their technical activities to support implementation of the human engineering Program Plan.

ACTIVITIES:

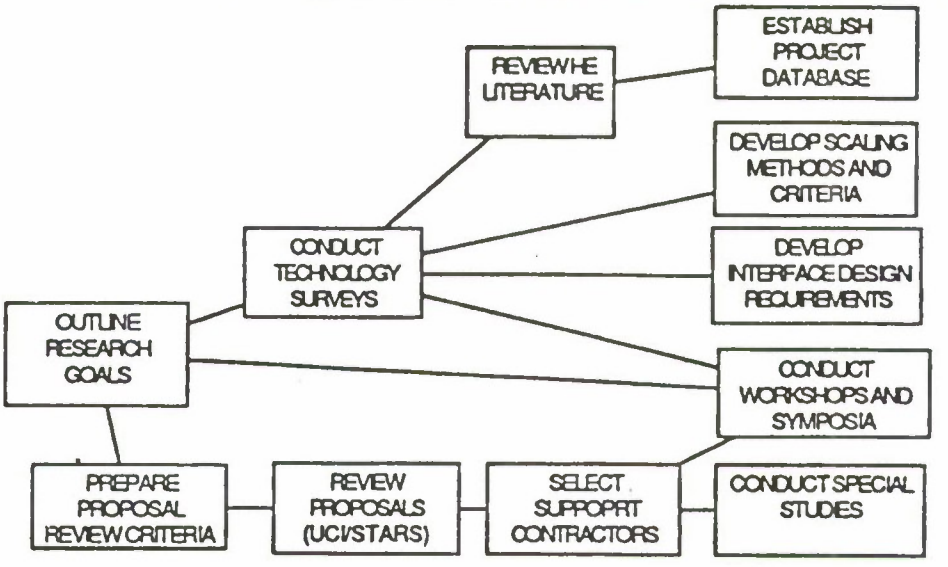
1. **Conduct coordination/strategy meetings with ACT representatives**
2. **Review ACT objectives and plans**
3. **Identify and resolve voids and duplications**
4. **Provide ongoing coordination/integration**

PRODUCT: Implementation of the human engineering Program Plan that ensures related activites and products are coordinated and integrated across the five ACTs.

Coordination and integration will be achieved through:

1. **Workshops and symposia**
2. **Electronic bulletin boards, newsletters, data bases, and E-mail networks**
3. **Report dissemination**
4. **Periodic status/coordination meetings**

HUMAN ENGINEERING FOR STARS



[---------- PHASE 3 - RESEARCH ----------]

OBJECTIVE: To review the state-of-knowledge and conduct research, as necessary, to achieve the objectives of the human engineering Program Plan

ACTIVITIES: 1. Outline research goals

2. Identify and select support contractors

3. Conduct technology surveys

4. Conduct workshops and symposia

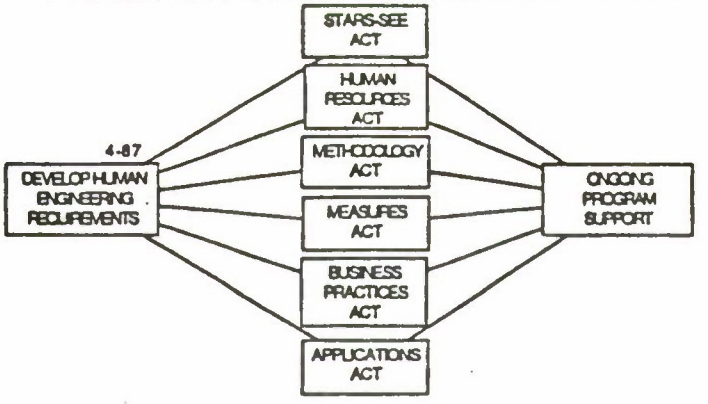
5. Conduct special studies

PRODUCTS: 1. Near- and long-term research goals

2. Reports on the state-of-knowledge for selected topic areas

3. Results of workshops, symposia, technology surveys and special studies

HUMAN ENGINEERING FOR STARS



[— PHASE 4 - REQUIREMENTS SPECIFICATION —]

OBJECTIVE: To prepare detailed human engineering design specifications for products originating from each of the five Area Coordinating Teams

ACTIVITIES:

1. Develop human engineering requirements and prepare specifications for each of the five area coordinating teams based on the results of Phase 3

2. Provide ongoing program support to interpret and implement requirements and specifications.

PRODUCTS: Human engineering requirements and specifications for ACT products.

Human engineering requirements and specifications will be prepared for:

1. **User-workstation interfaces for STARS-SEE workstations**
2. **Human engineering methods and criteria applicable to all phases of the software acquisition process**
3. **Training systems and devices for SEE users and product end-users**
4. **Methods and criteria for scaling users, systems and environments**
5. **UCI rapid prototyping design and evaluation methods**

ATTACHMENT M.5

UCI/STARS WORKSTATION INTEROPERABILITY CONSORTIUM

Relationship to UCI subTAG

Voluntary and cooperative group of key industry and technical society professionals in UCI domain supporting goals and objectives of UCI SubTAG

SCOPE

1. Provide forum for information exchange and liaison between government, technical societies and industry groups (e.g., TS/IC).

2. Explore common areas of current need

3. Define common needs and objectives - UCI tools, methods and references

4. Support UCI TAG - integrated, cooperative R&D efforts in areas of defined needs

5. Develop recommendation for consideration by UCI TAG in areas of UCI - STDs, guidelines, tools, methods, ongoing research

GOALS

1. Reduce training needs by maximizing the transferability of learning among interfaces

2. Exhance operability and interoperability

3. Reduce overall system life cycle costs

4. Increase productivity

5. Improve system readiness/effectiveness

6. Identify research voids and minimize duplication of effort

7. Extend the UCI technology base

TASKS

1. Support workshops/symposia
2. Identify existing techinal information sources
3. Conduct studies to define mutual needs for UCI
4. Support cooperative R & D efforts
5. Plan and conduct R & D efforts
6. Synthesize findings from R&D efforts and provide recommendations for additional research/future advancements

PRODUCTS

- Inputs and recommendations for symposia and workshops
- Database of Industry and government UCI resources
- Inputs to UCI technology needs summary
- Research reports and project cards
- Inputs to near-term and long-term research plans

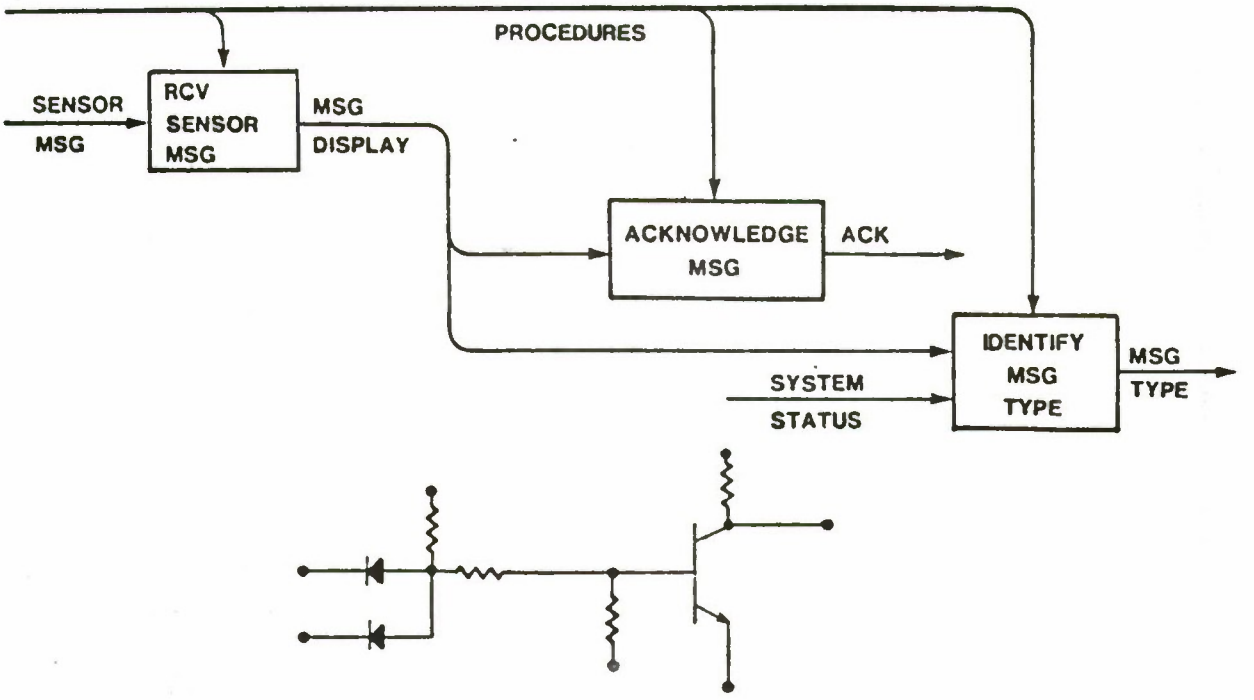
ATTACHMENT M.6

COPE/RIPL

COPE TECHNOLOGY

- INTEGRATED ANALYSIS TECHNIQUES FOR C^3 SYSTEMS
- ADAPTIVE OPERATOR AIDING
- INTEGRATED C^3 WORKSTATION CONCEPTS
- TOUCH-SENSITIVE DISPLAY INVESTIGATIONS
- DECISION-MAKING IN C^3
- GROUP PROBLEM SOLVING
- LARGE DISPLAY EVALUATIONS
- HCI DESIGNER SUPPORT STATION

INTEGRATED ANALYSIS TECHNIQUES
IAT



AIR FORCE AEROSPACE MEDICAL RESEARCH LABORATORY

INTEGRATED ANALYSIS TECHNIQUES

PROBLEM

- HOW DO YOU DESCRIBE THE HUMAN ELEMENT IN C^3 SYSTEMS
- WHAT ARE HUMAN MOP AND HOW DO THEY RELATE TO SYSTEM MOE

OBJECTIVE

- INCLUDE HUMAN PERFORMANCE IN A STRUCTURED ANALYSIS AND DESIGN PROCESS
- DEVELOP FRAMEWORK FOR MAN-IN-THE-LOOP SIMULATION AND DATA COLLECTION

APPROACH

- AUGMENT $IDEF_0$ TECHNIQUE TO FORM A SYSTEM DESCRIPTION FRAMEWORK
- INTERFACE TO SAINT
- CONDUCT EXPERIMENTATION TO DEVELOP HUMAN PERFORMANCE DATA BASE

STATUS

- $IDEF_0$ APPLIED AT NORAD W'TH EXCELLENT SUCCESS
- INTERFACE WITH SAINT HAS BEEN TESTED ON A THREAT SYSTEM SIMULATOR
- OPERATIONAL MEASURES BEING DEVELOPED FROM NORAD STUDIES

DIMENSIONS FOR ANALYZING C^3 SYSTEM STRUCTURE

1. GOALS - CAPTURE THE REQUIREMENTS/CONSTRAINTS THAT MISSION OBJECTIVES IMPOSE
2. ORGANIZATIONS - SITE OF CONTROL OR AUTHORITY; PERSONNEL PLAY ROLES AT DIFFERENT LEVELS OF ORGANIZATION, AND HAVE RESPONSIBILITIES ALLOCATED TO THEM
3. PROCESSES - ACTIVITIES CARRIED OUT TO FULFILL GOALS
4. RESOURCES - AGENTS (MAN OR MACHINE); EQUIPMENT, MATERIALS, PHYSICAL LAYOUT OF COMPONENTS AND THEIR CONNECTIONS

ISSUES RELEVANT TO ADAPTIVE AIDING

- FOCUS OF ADAPTATION
- METHOD OF ADAPTATION
- NATURE OF COMMUNICATION
- WHO'S IN CHARGE?
- COMPUTER DECISION MAKING

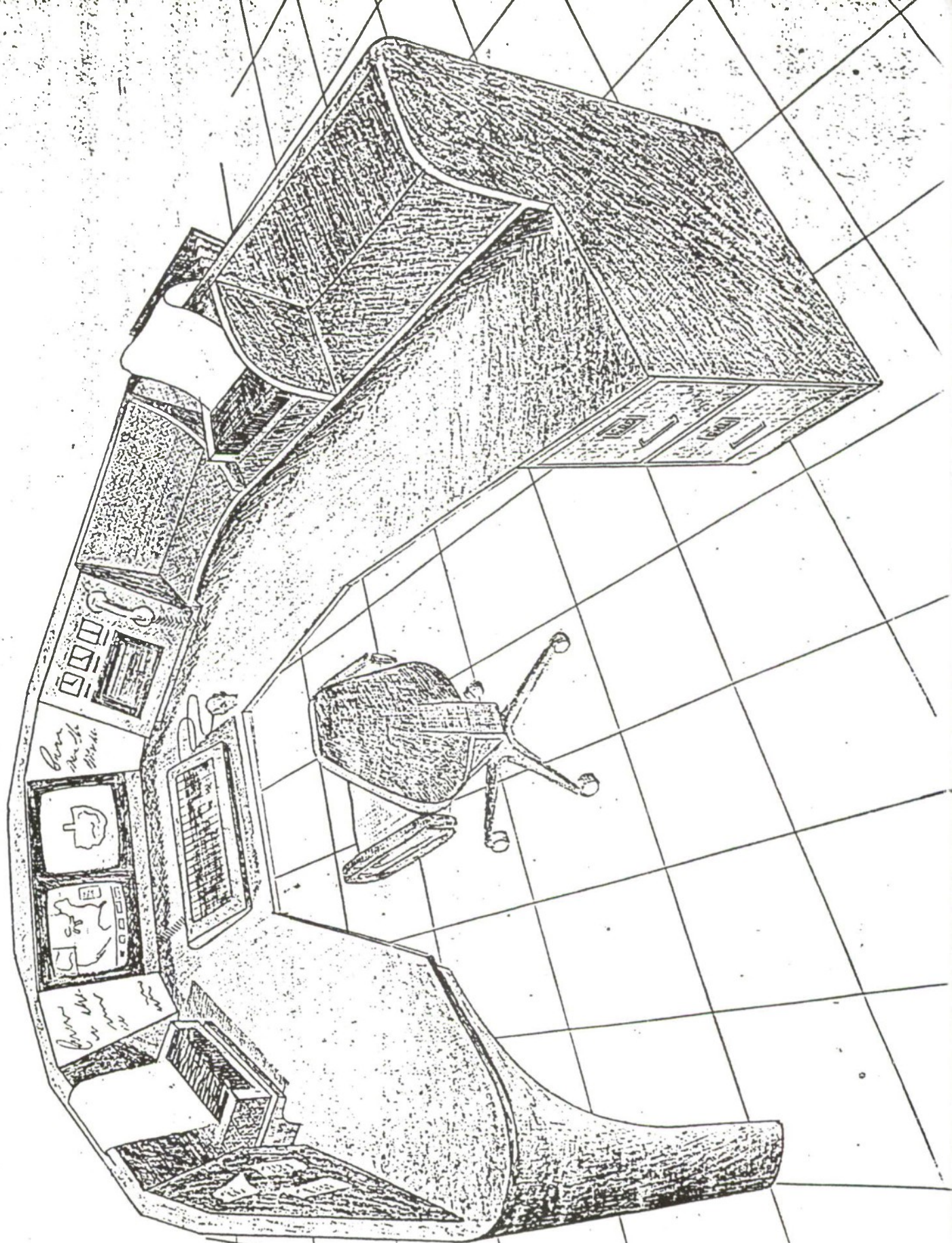
GOALS OF RESEARCH

- IDENTIFY PRINCIPLES OF ADAPTIVE AIDING
- DETERMINE CONDITIONS IN WHICH HUMANS CAN BE IN CHARGE
- PROVIDE EXPERIMENTAL RESULTS TO SERVE AS BASES FOR DESIGN GUIDELINES

COPE PROTOTYPE WORKSTATION

PERFORMANCE ISSUES:

- DISPLAY FORMATS
- DATA ENTRY (VOICE, TOUCH)
- VOICE SYNTHESIS (PROMPTS)
- COMMUNICATION MANAGEMENT
- STATION FLEXIBILITY
- PHYSICAL DESIGN (PROFILE, LIGHTING)



- SPACECMD/NORAD EVALUATIONS AND DESIGN RECOMMENDATIONS
- SOPC--IDENTIFIED PROBLEM AREAS FOR PROPOSED SOPC DESIGN
- JOINT TACTICAL FUSION PROGRAM--HUMAN FACTORS RECOMMENDATIONS
- NATIONAL MILITARY INTELLIGENCE CENTER EVALUATION AND RECOMMENDATIONS
- OJCS--COMMAND CENTER IMPROVEMENT PROGRAM
- TOUCH SENSITIVE DISPLAY GUIDELINES FOR C^3 APPLICATIONS
- RECOMMENDATIONS FOR APPLICATION OF LARGE DISPLAYS
- SPACECMD ADVANCED INTEGRATED WORKSTATION DEMONSTRATION

C^3 OPERATOR PERFORMANCE ENGINEERING (COPE)
PE # 62202F / PROJECT # 7184

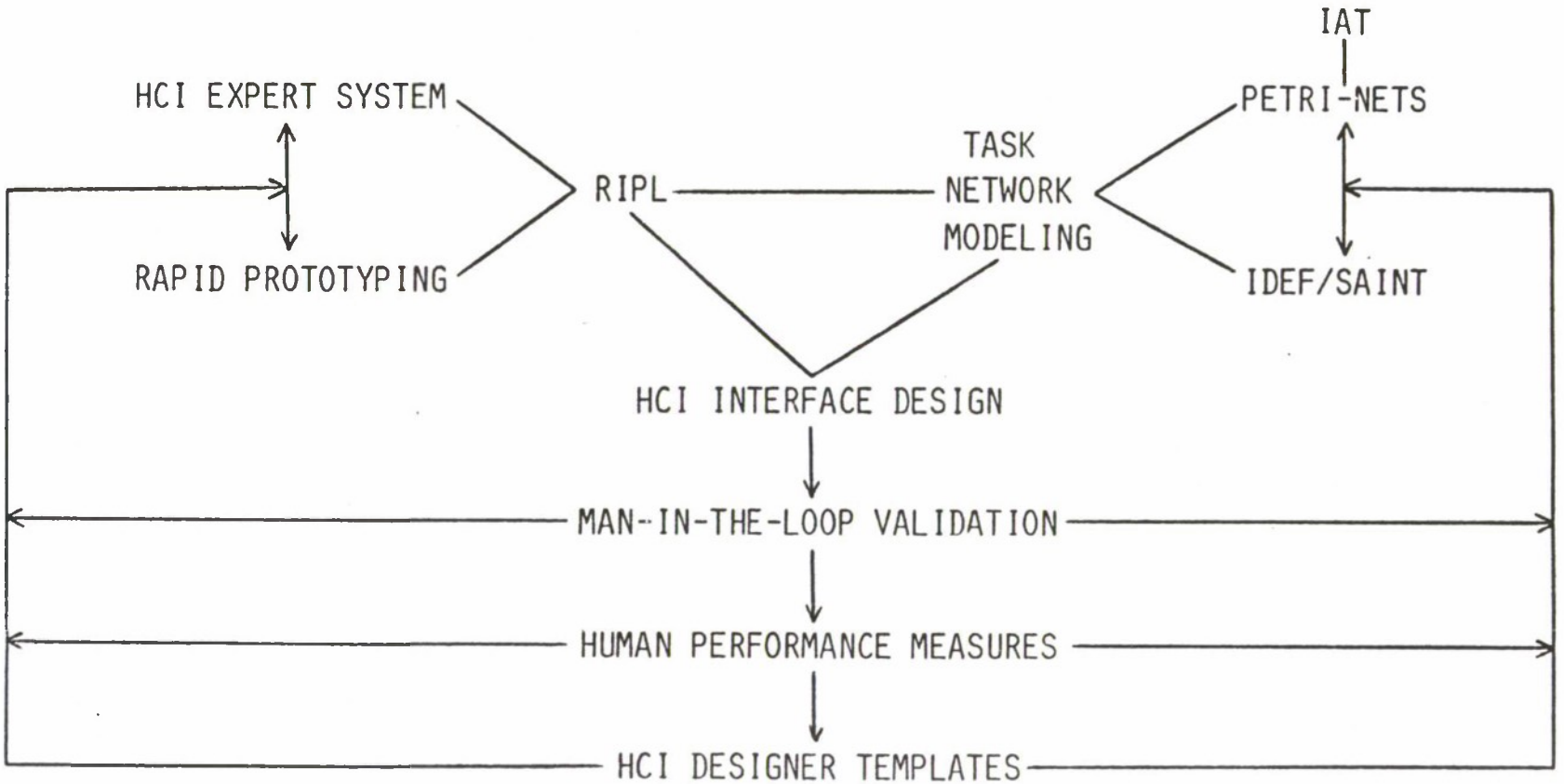
OBJECTIVES:

- DEVELOP TECHNIQUES TO DESCRIBE AND ANALYZE C^3 SYSTEMS
- CHARACTERIZE HUMAN PERFORMANCE IN C^3 SYSTEMS
- ESTABLISH GUIDELINES FOR C^3 STATION DESIGN

MILESTONES:

- ADVANCED INTEGRATED C^3 WORKSTATION 1985
- USERS MANUAL FOR C^3 SYSTEM ANALYSIS METHODOLOGY 1986
- APPLICATIONS OF LARGE DISPLAYS TO C^3 SYSTEMS 1987
- REPORT: ADAPTIVE AIDING FOR C^3 1987
- INTEGRATED ANALYSIS TECHNIQUES FOR C^3 SYSTEMS 1988
- HANDBOOK OF C^3 WORKSTATION DESIGN 1988

HCI DESIGNER'S SUPPORT STATION



RIPL

RAPID INTELLIGENT PROTOTYPING LABORATORY



DEFINITION RIPL

R apid - EASY TO LEARN AND USE

I ntelligent - CONTAINS USI GUIDELINE EXPERTISE

P rototyping - SIMULATES THE USI OF AN APPLICATION

L aboratory - A HARDWARE AND SOFTWARE ENVIRONMENT

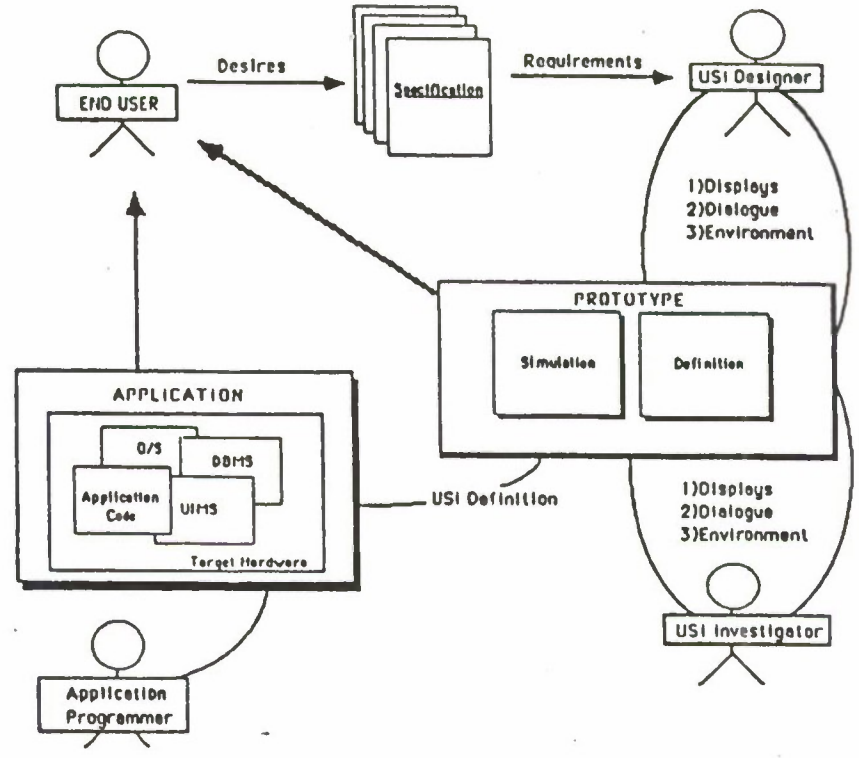
TECHNICAL APPROACH RIPL

1) EXPERT SYSTEM - RIPL incorporates two expert systems:
   - a Mycin like consultant expert system that responds to general USI information requests (e.g. Tell me about tabular data presentation) ; and
   - an evaluation expert system that interprets the current definition of dialogues and displays (e.g. Use of yellow on top of orange is not recommended).

2) KNOWLEDGE BASE - RIPL incorporates the Smith & Mosier guidelines in three ways:
   - In a "help by example" facility;
   - In the implementation of RIPL(i.e. limit the user's options); and
   - In the USI expert systems knowledge base (same rule base for both experts).

3) PROTOTYPE SEMANTICS - RIPL combines a direct manipulation user interface with a graphical ellipsis dialogue interpreter to minimize the prototype and semantic definition overhead.

4) HARDWARE SUITE - Use of the VAX architecture and the GKS standard allows a wide range of upward migration paths for processing power and display capability.



MAJOR FUNCTIONS RIPL

EXECUTIVE

Sets up all necessary file and library accesses.
Performs housekeeping functions of deleting, renaming and backing up RIPL files and libraries.

PROTOTYPE BUILD SUBSYSTEM

Defines screen contents, interactions, and target environment.
Instruments dialogue.

SIMULATION SUBSYSTEM

Compiles simulation components.
Simulates, records, and measures the USI design.

USI ADVISORY SUBSYSTEM

Consults on and/or evaluates design.

TECHNICAL LIBRARIAN

Provides for browsing of guidelines and examples.
Provides help on using RIPL.

INPUT:

1. DISPLAY CONTENT
2. PHYSICAL OPERATING ENVIRONMENT
3. DIALOGUE STRUCTURE
4. SIMULATION PARAMETERS
5. APPLICATION OPERATING ENVIRONMENT

OUTPUT:

1. STRUCTURED DIALOGUE DEFINITION
2. DESIGN CONSULTATION
3. DESIGN EVALUATION
4. DESIGN SIMULATION
5. CAPTURE OF USER INTERACTION DURING SIMULATION
6. INSTRUMENT MEASURES

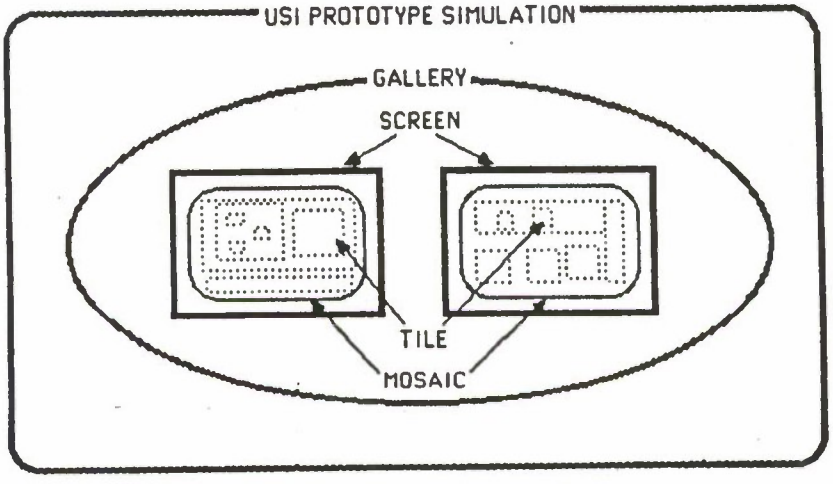
TERMINOLOGY RIPL

STATICS

- o tile - a rectangular area, less than or equal to a screen in a size, having specific attributes and contents. A tile is similar to the graphics term - viewport, except that there is no notion of a larger virtual screen area behind it. Tiles may be grouped in a hierarchy where tiles that are contained in the area defined by larger tiles inherit some of their attributes. The attributes of a tile are dependent on its position in the hierarchy.
- o mosaic - the contents of a user activity screen on a single workstation at any one time. Each mosaic is composed of a hierarchy of tiles.
- o gallery - the collection of all the user activity screens on all displays at any one time.

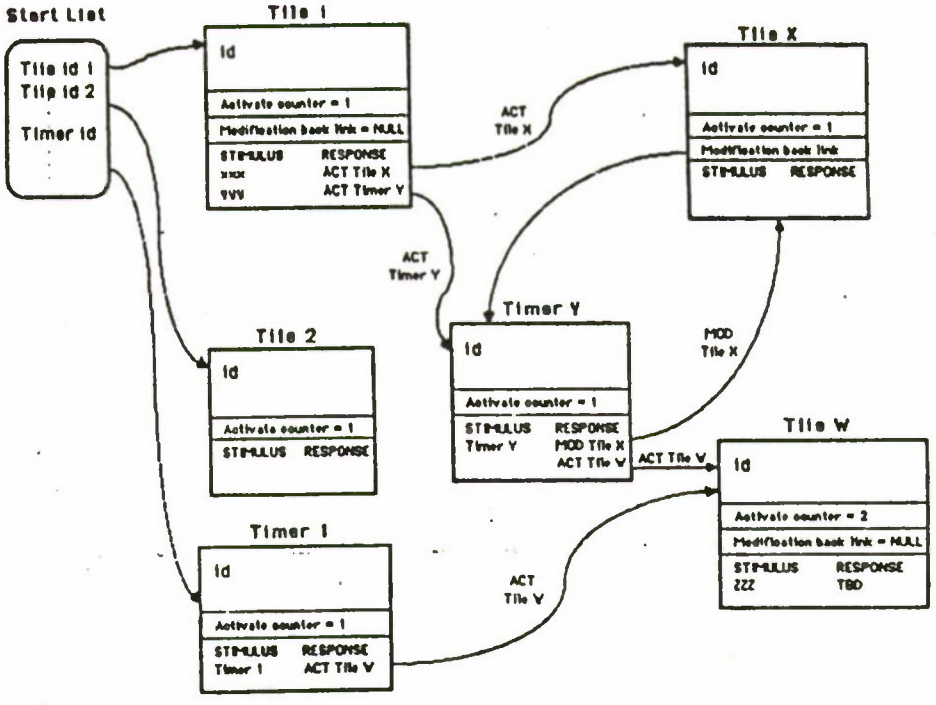
DYNAMICS

- o thread - a single chain of stimulus-responses originating with the simultaneous activation of a set of tiles.

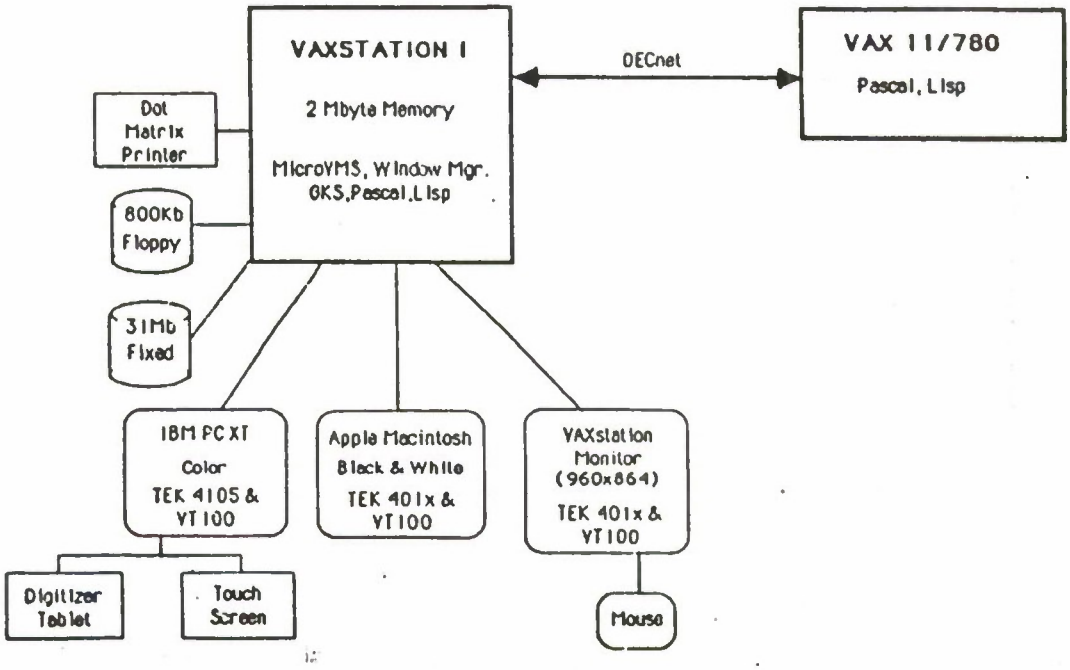


TILE DEFINITION RIPL

- IDENTIFICATION - NAME + ID NUMBER
- CONTENT - (text/table/menu/bit map/display list ...)
- SEMANTIC USE - (error, map, title, status ...)
- LIST OF ATTRIBUTE INSTANCES (position, size, border, view, cursor ...)
- LIST OF CONTENT INSTANCES
- LIST OF STIMULUS-RESPONSES



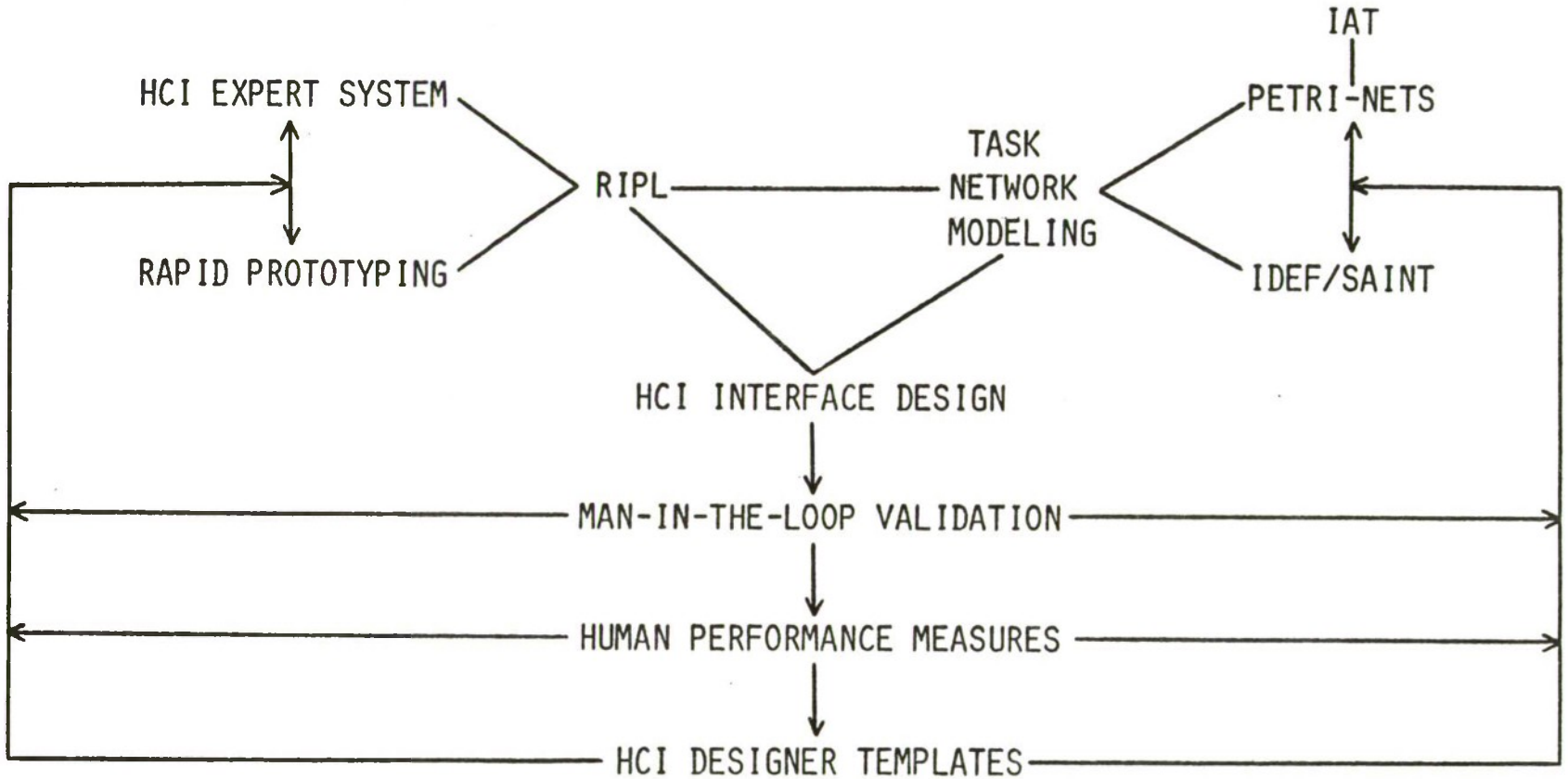
- PROVIDES ON-LINE DOCUMENT ACCESS
- FACILITATES RAPID INFORMATION SEARCH
- FUNCTIONS AS RIPL HELP SYSTEM
- FUNCTIONS AS USI GUIDELINE RETRIEVAL SYSTEM



Approach

1. Select a class of human-computer interaction problems.
2. Develop a standard task for this problem area.
3. Develop several alternative strategies for solving the task
4. Develop task network models for these strategies.
5. Set model parameters via several techniques.
6. Collect laboratory data on subjects performing the tasks using the modeled strategies.
7. Compare model predictions to actual data.

HCI DESIGNER'S SUPPORT STATION



ATTACHMENT M.7

IDB DEMONSTRATION INSTRUCTIONS

INSTRUCTIONS FOR DIALING UP THE THE IDB DEMO

YOU: DIAL (614) 424-5850 (300 Baud)* ; when your modem completes the connect, proceed
or
DIAL (614) 424-5450 (1200 Baud)*

YOU: <CR><CR><CR>... ; HIT <CR> several times until VAX responds

VAX: XX-XX IS4000

VAX: DESTINATION?

YOU: vms<CR> ; enter "vms"

VAX: PAUSE

VAX: CONNECTED TO XX-XX

YOU: <CR><CR><CR>... ; Hit <CR> key several times until you get a USERNAME prompt

VAX: USERNAME

YOU: demodb<CR> ; enter this

VAX: PASSWORD

YOU: Interface<CR> ;enter this.

VAX: ACCOUNT #

YOU: 1014283 ; enter this. After a pause the IDB demo begins

VAX: WELCOME TO VAX/VMS...

IDB: USERNAME

YOU: demodb<CR> ; enter this

IDB: PASSWORD

YOU: Interface<CR> ; enter this, you should now be in IDB

NOTE: The only legal search term is "ABBREVIATIONS.

If you have any questions please call Lou Myers (614) 424-7166

*(8 Bits, No Parity, 1 Stop Bit, ECHO=N)

ATTACHMENT N

VOICE-INTERACTIVE SYSTEMS -- ATTENDEE

LIST AND AGENDA

DEPARTMENT OF DEFENSE

HUMAN FACTORS ENGINEERING

TECHNICAL ADVISORY GROUP

VOICE-INTERACTIVE SYSTEMS

5 November 1985/San Diego, California

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785-6696

AGENDA

VOICE INTERACTIVE SYSTEMS SUBTAG MEETING

5 November 1985

1330 - 1625 Teak Room, Kona Kai Resort, San Diego

WELCOME AND ANNOUNCEMENTS
Clay Coler, Chairman, Voice SubTAG

BUSINESS MEETING:
ROADMAPS, ARPANET, AND OTHER BUSINESS

Presentation: NOSC'S ROLE IN SPEECH RECOGNITION AND SYNTHESIS
Elaine Schiller, Naval Ocean Systems Center, San Diego

- Coffee Break -

Presentation: AN ARCHITECTURE FOR PARALLEL PROCESSING IN SPEECH RECOGNITION: THE TRACE MODEL
Jeff Ellman, Phonetics Laboratory, University of California at San Diego

Presentation: INTERFERENCE REDUCTION
Stephen Smith, Rome Air Development Center, Griffiss AFB, Rome, New York

AGENDA

VOICE INTERACTIVE SYSTEMS SUBTAG MEETING

8 November 1985

0830 - 1200 Naval Ocean Systems Center, San Diego

WELCOME
Clay Coler, Chairman, Voice SubTAG

Presentation: VOICE INTERACTIVE AVIONICS (VIA) FLIGHT TEST PREPARATIONS
Lockwood Reed, U.S. Army Avionics R & D Activity, Ft. Monmouth, New Jersey

Presentation: SOFTWARE METHODOLOGY FOR AUTOMATED RECOGNITION TRAINING (SMART)
David Williamson, AFWAL/FIGR, Wright-Patterson AFB, Ohio

Presentation: VOICE RESEARCH AT THE HUMAN ENGINEERING LABORATORY
Kathy Christ, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

- Coffee Break -

Presentation: APPLICATION OF CONNECTED SPEECH RECOGNITION TO TACTICAL VOICE COMMAND AND SPEAKER AUTHENTICATION
Robert Wohlford and B. Patrick Landell, ITT Defense Communications Division, San Diego

Presentation: DARPA SPEECH RESEARCH
Tice DeYoung, SPAWARSYSCOM, Washington, D.C.

ATTACHMENT O

HUMAN ENGINEERING GUIDE TO SYSTEMS AND EQUIPMENT

DEVELOPMENT -- VIEW GRAPHS

STATUS: NRC/NAS RECOMMENDATIONS

- NRC CONSIDERS NEED TO REVISE HEGED BY REQUEST... OCTOBER 1983

- NRC CANNOT UNDERTAKE OR SUPERVISE REVISION

- RESERVATIONS RE: PRINTED HANDBOOK FORMAT...

- SUGGESTS CONSIDERATION OF ALTERNATIVE ELECTRONIC FORMAT

  - TELEPHONE ACCESSIBLE
  - CASE OF UPDATE

INTEGRATED PERCEPTUAL INFORMATION FOR DESIGNERS

IPID INFORMATION MANAGEMENT OBJECTIVES

		PRODUCTS
• CONSOLIDATION	→	HANDBOOK
• PRESENTATION	→	DATA COMPENDIUM
• ACCESSIBILITY	→	AUTOMATED DATA BASE MANAGEMENT SYSTEM

- HANDBOOK OF PERCEPTION AND HUMAN PERFORMANCE
  - PUBLICATION: MAR-APR 1986
  - 45 CHAPTERS: 3000 PAGES: 2 VOL
  - BOFF, K.R., KAUFMAN, L., AND THOMAS J. (EDS.). HANDBOOK OF PERCEPTION AND HUMAN PERFORMANCE. JOHN WILEY & SONS, NEW YORK, 1985.

- ENGINEERING DATA COMPENDIUM: HUMAN PERCEPTION AND PERFORMANCE
  - PROTOTYPE DEVELOPED AND DISTRIBUTED: APRIL 1985
  - EXPECTED COMPLETION: SPRING 1986
  - 3 VOLUMES: 1200 ENTRIES

DESIGNERS ASSOCIATE

- CHARACTERIZE OPTIMAL DoD DESIGN PROCESS
- DEFINE TOOLS AND DATA BASES NEEDED
- CONFIGURE WORK STATION CONCEPT
  - — CONDUCT TRADEOFF ANALYSIS
  - — BLUEPRINT PERSPECTIVE ARCHITECTURES

DESIGNER'S ASSOCIATE

AUTOMATED DATA MANAGEMENT FOR DESIGNERS

- ENCODES
  - — IPID HUMAN PERFORMANCE DATA
  - — BIOTECHNOLOGY AND SYSTEMS DESIGN DATA
- FUNCTIONS AS A "PROBLEM-SOLVING" PARTNER
  - — USER FRIENDLY
  - — HELPS FORMULATE RELEVANT QUESTIONS
  - — TAILORS QUESTIONS TO INFORMATION RESOURCES
  - — HELPS DEVISE RETRIEVAL STRATEGIES
  - — EXPLAINS AND QUALIFIES ANSWERS THAT COME BACK
  - — DECISION AIDING

HUMAN PERCEPTION AND PERFORMANCE SHORT COURSE

- OBJECTIVE: PROVIDE SYSTEM DESIGNERS A HUMAN PERFORMANCE FRAMEWORK FOR DECOMPOSING EQUIPMENT RELATED DESIGN PROBLEMS ·
- WHEN: APRIL 7 - 11, 1986
- WHERE: BERGAMO CONFERENCE CENTER, DAYTON OHIO
- ENROLLMENT: 100 PARTICIPANTS (50 GOVERNMENT, 50 INDUSTRY)
- FOR FURTHER INFORMATION CONTACT:

DR. KENNETH R. BOFF
(513) 255-7596 OR 7602
AV 785-7596 OR 7602

ATTACHMENT P

HUMAN PERFORMANCE MEASUREMENTS

TUTORIAL -- OVERVIEW

Department of Defense

Human Factors Engineering
Technical Advisory Group

TUTORIAL

Selecting Performance Measures in HFE Testing and Research

PERFORMANCE MEASURES TUTORIAL

OVERVIEW

- Introduction
  - Why Is the Subject Important?
  - What Are the Theoretical Issues?
- The Army Experience
- The Navy Experience
- The Air Force Experience
- The Industry Experience
- Open Discussion
- Summary and References

PANELISTS

Army — James C. Geddie, PhD

Navy — Dennis K. McBride, PhD

Air Force — Stephen M. Rokicki, PhD

APA/21 — Frederick A. Muckler, PhD

MODERATOR

John L Miles, Jr., J.D.

PERFORMANCE MEASURES TUTORIAL

WHAT **IS** A "PERFORMANCE MEASURE"?

NO ANSWER IN:

- A Comprehensive Dictionary of Psychological and Psychoanalytical Terms
- Dictionary of Psychology
- Dictionary of Weapons and Military Terms
- Handbook of Evaluation Research
- Handbook of Psychological Terms
- Modern Science Dictionary

WHAT'S THE **PURPOSE** OF A "PERFORMANCE MEASURE"?

To Select from the Many Facets of Observable Activity One Which Is Assessable in Relevant, Meaningful Quantifiable Units.

WHY DOES IT MATTER HOW WE SELECT "PERFORMANCE MEASURES"?

- Validity of Our Technology
- Communication of Our Findings
- Construction of Data Bases

PERFORMANCE MEASURES TUTORIAL

WHAT IS THE ONE, BEST, UNIVERSAL "PERFORMANCE MEASURE"?

(We Haven't Found It Yet.)

MOST COMMONLY USED HUMAN PERFORMANCE MEASURES

— Time

— Accuracy*

*For Convenience, We Customarily Measure Error, Assuming Accuracy= $\frac{1}{\text{Error}}$

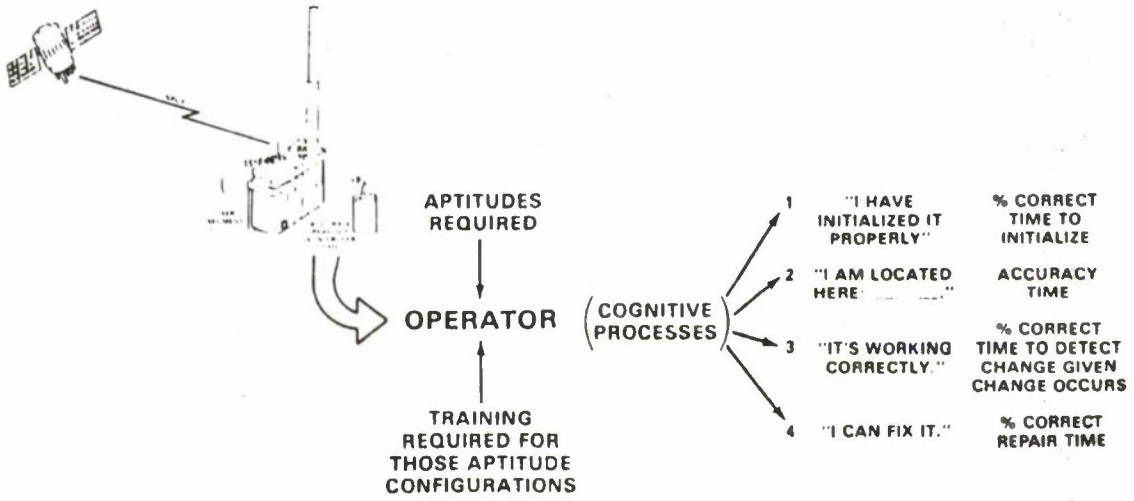
MANPRINT RULE THREE

Measure Soldier Performance by Time and Accuracy



PERFORMANCE MEASURES TUTORIAL

MANPRINT CONCEPT OF "SYSTEM" EFFECTIVENESS



WHAT IS THE IDEAL **SOURCE** OF "PERFORMANCE MEASUREMENT"?

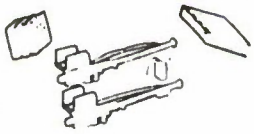
The System Requirements Document Contains:



- Soldier Performance Standards
- Soldier Characteristics



- Maximum Tolerable Training Burden





COMMON PROBLEMS WITH "PERFORMANCE MEASURES"

- Set Too Broadly
- Set Too Narrowly
- Fails to Discriminate
- Unrelated to Military Concerns

ATTACHMENT Q

BIBLIOGRAPHY ON PERFORMANCE MEASUREMENT

Department of Defense
Washington, DC 20310

BIBLIOGRAPHY
ON
PERFORMANCE MEASUREMENT

HUMAN FACTORS ENGINEERING
Technical Advisory Group

November, 1985

Part One

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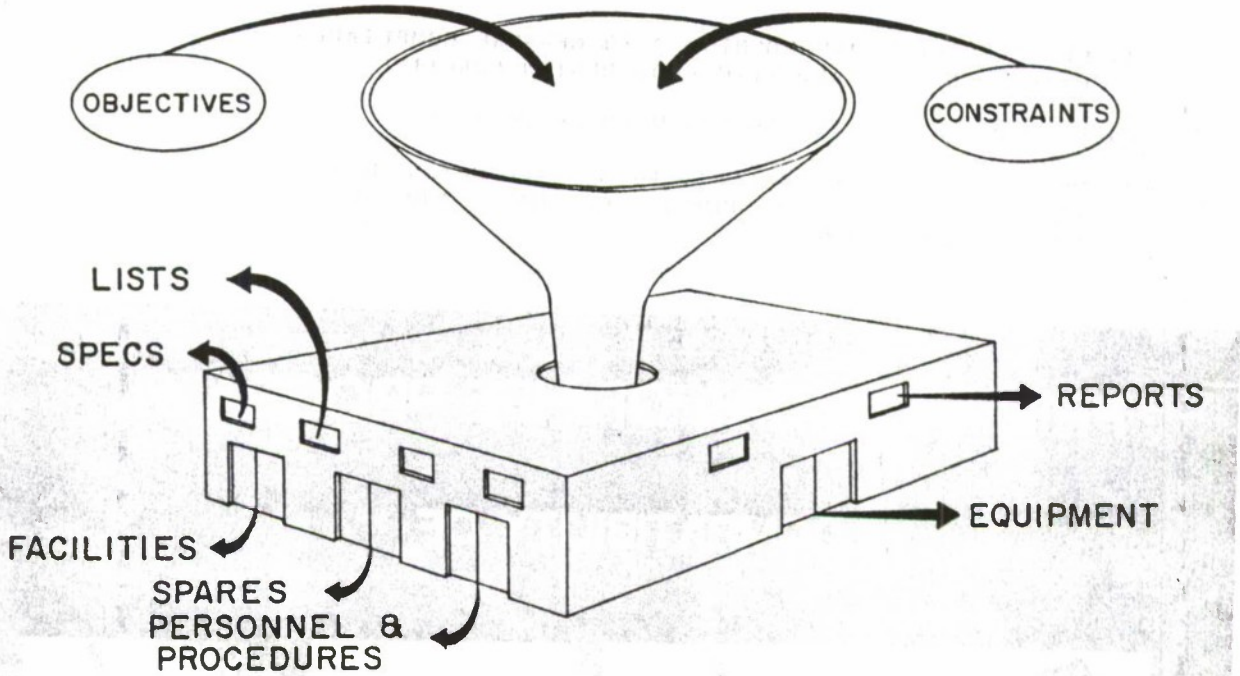
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ATTACHMENT R

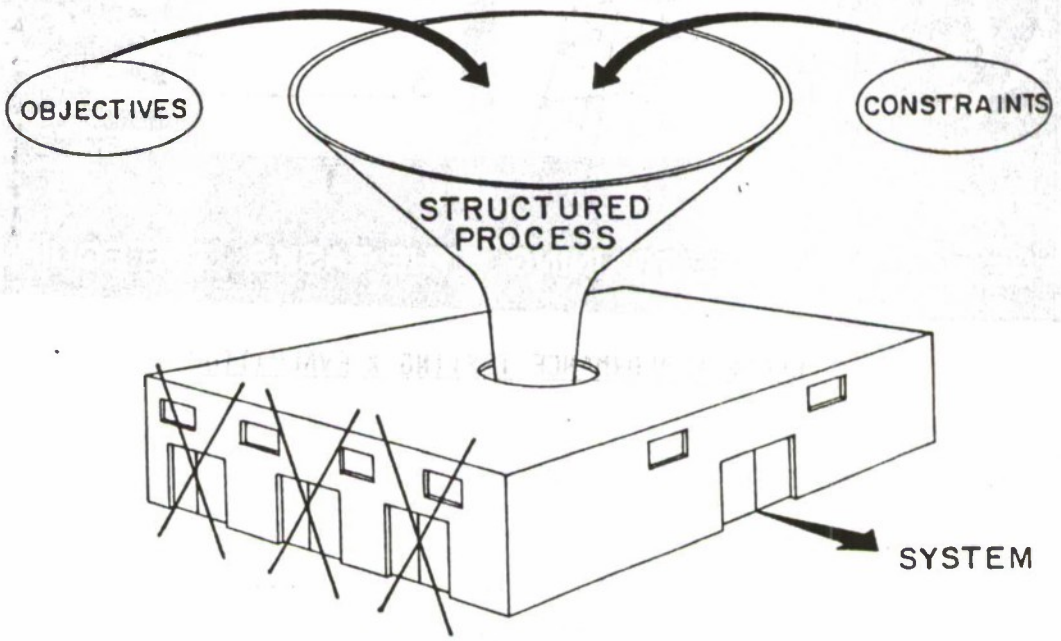
HUMAN PERFORMANCE MEASUREMENT CONTEXT

AND CONTENT (ARMY)

TRADITIONAL APPROACH



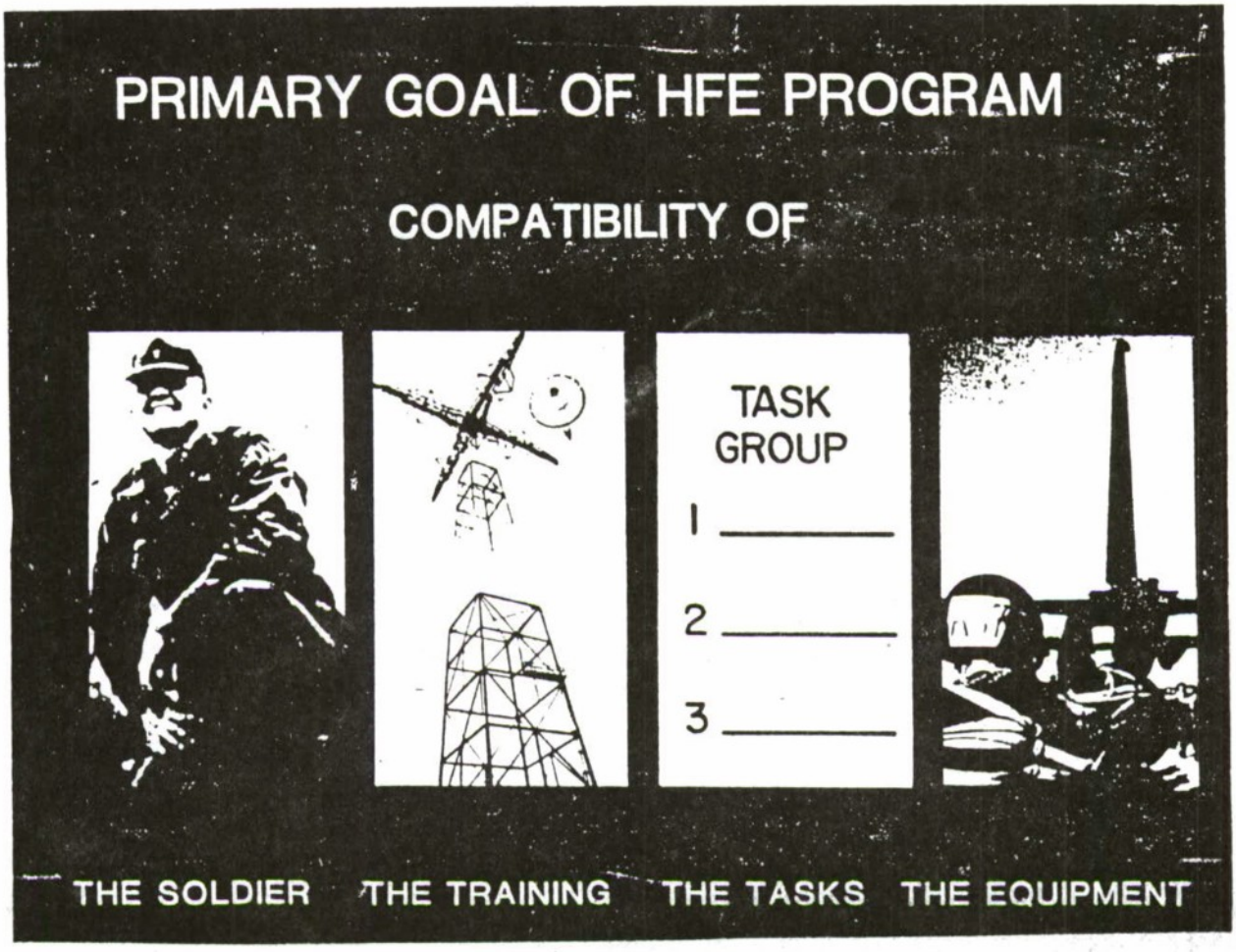
SYSTEM ENGINEERING APPROACH



HUMAN FACTORS ENGINEERING EVALUATION

KINDS OF DATA REQUIRED

1. ENGINEERING MEASUREMENTS -- TO MEASURE COMPLIANCE WITH STANDARDS AND WITH GOOD DESIGN PRACTICE
2. USER OPINION -- TO ASSESS USER ACCEPTANCE
3. HUMAN PERFORMANCE DATA -- TO MEASURE HUMAN-MACHINE INTERFACE EFFECTS ON HUMAN PERFORMANCE AND ON SYSTEM PERFORMANCE



HUMAN PERFORMANCE TESTING & EVALUATION

1. RECORD TEST PARTICIPANT DEMOGRAPHICS.
2. IDENTIFY CRITICAL TASKS.
3. EXERCISE TASKS AND MEASURE HUMAN PERFORMANCE:
    A. HUMAN PERFORMANCE TIME
    B. HUMAN PERFORMANCE ERROR RATE
4. COMPARE PERFORMANCE TO CRITERIA.
5. EVALUATE AND MAKE RECOMMENDATIONS.

ATTACHMENT S

AN ANNOTATED BIBLIOGRAPHY OF OBJECTIVE PILOT PERFORMANCE MEASURES (NAVY TECHNICAL REPORT)

V
90

Technical Report: NAVTRAEQUIPCEN IH-330

AN ANNOTATED BIBLIOGRAPHY OF OBJECTIVE PILOT PERFORMANCE MEASURES

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Department of Operations Research
Naval Postgraduate School
Monterey, California 93940

January 1982

FINAL REPORT FEBRUARY - SEPTEMBER 1981

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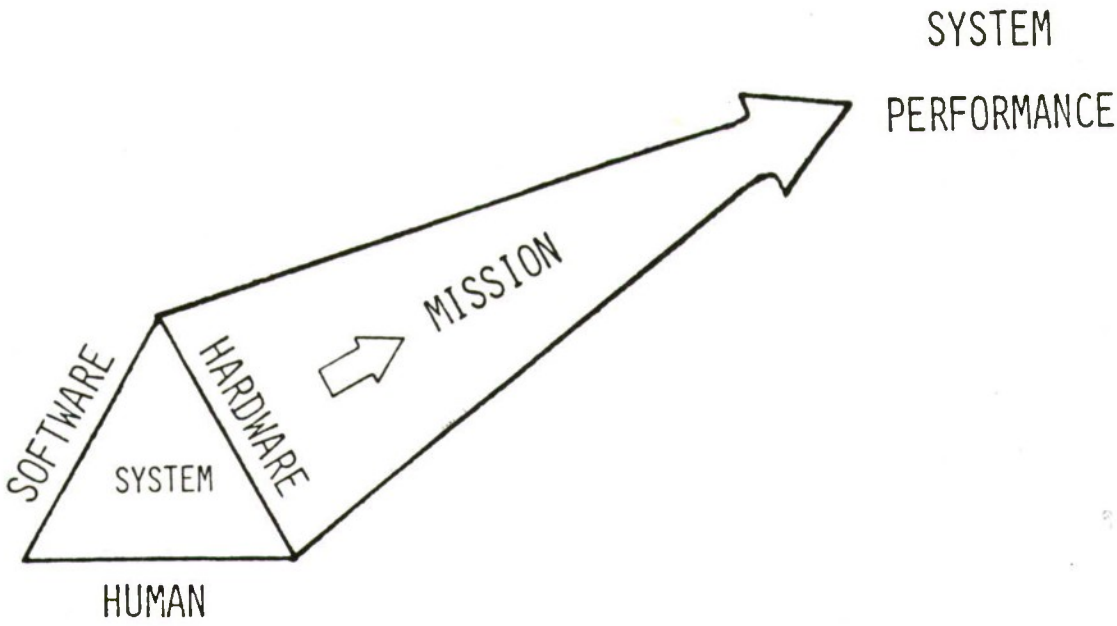
ATTACHMENT T

HUMAN PERFORMANCE EVALUATION IN

AIR FORCE OT&E

HUMAN PERFORMANCE EVALUATION IN AIR FORCE OT&E

STEPHEN M. ROKICKI, PH.D.
CHIEF, HUMAN FACTORS BRANCH
AF OPERATIONAL TEST & EVALUATION CENTER

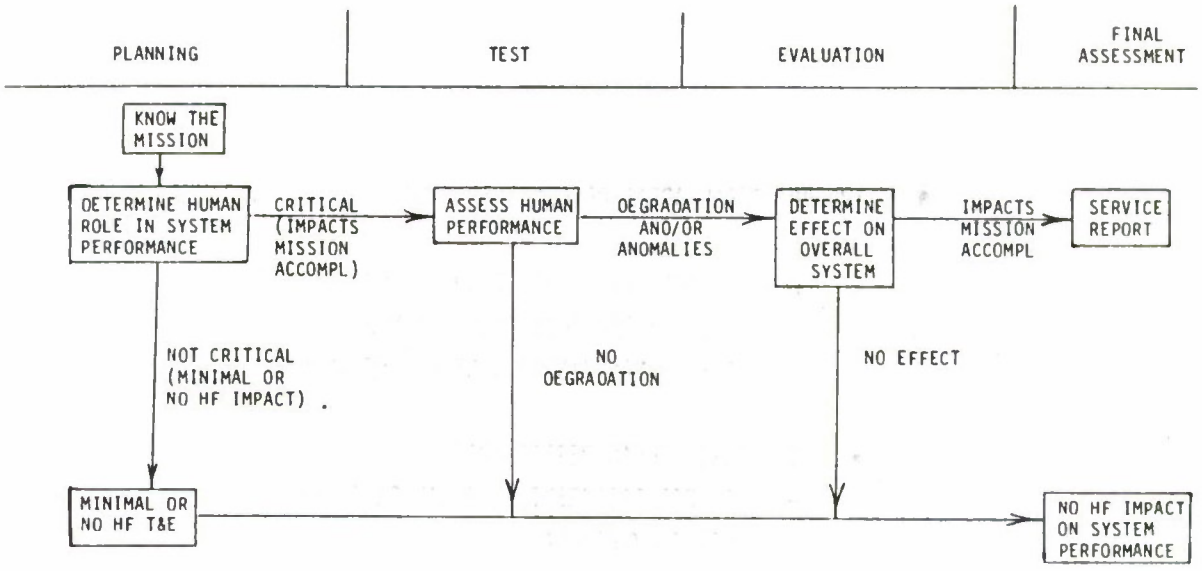


METHODOLOGIES USED IN
HUMAN FACTORS EVALUATIONS

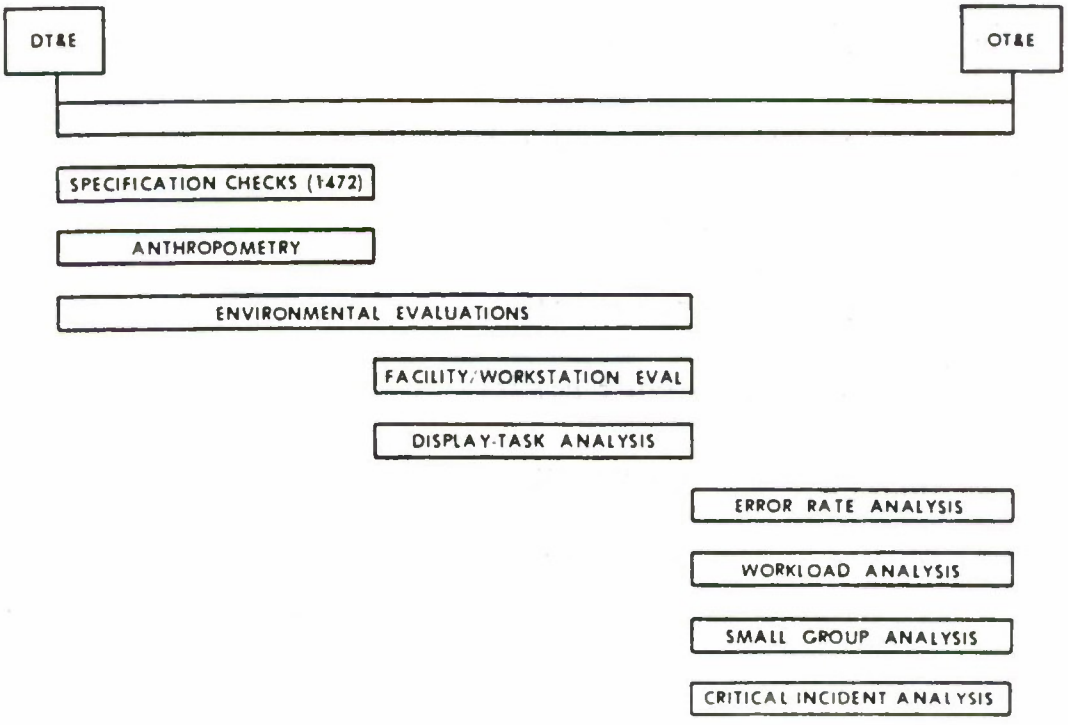
HUMAN FACTORS OT&E

METHOOOLOGY

APPROACH



HUMAN FACTORS EVALUATION METHODS



HUMAN FACTORS OT&E TECHNIQUES

- TWO PRINCIPAL AREAS OF CONCENTRATION
  - DYNAMIC MAN-SYSTEM AND GROUP INTERACTION
    - DOES SYSTEM CONSTRAIN HUMAN ROLE
    - DOES HUMAN HINDER SYSTEM PERFORMANCE
  - INTRINSIC HUMAN PERFORMANCE
    - PHYSIOLOGIC/PSYCHOLOGICAL DECREMENT
    - FATIGUE/WORKLOAD

EVALUATION TECHNIQUES

- WORKLOAD ANALYSIS
- FACILITY & WORKSTATION EVALUATION
- ERROR RATES
- DISPLAY-TASK ANALYSIS
- ENVIRONMENTAL EVALUATION
- SMALL GROUP ANALYSIS
- BEHAVIORAL ANALYSIS

WORKLOAD ANALYSIS

HOW:
- SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE (SWAT) (0-100 WORKLOAD SCALING METHOD)
- MODIFIED COOPER-HARPER SCALE - (1-10 WORKLOAD SCALE)
- SECONDARY EMBEDDED TASKS
- OBSERVATIONS
- VISUAL FATIGUE TESTING (CONTRAST SENSITIVITY)
- PHYSIOLOGICAL CORRELATES (HT RATE)
- SUBJECTIVE FATIGUE SURVEY

WHY:
- HIGH WORKLOAD DEGRADES OPERATOR PERFORMANCE

FACILITY & WORKSTATION EVALUATION

HOW:
- SYSTEM LAYOUT
- CONSOLE LAYOUT

WHY:
- IDENTIFY IF SYSTEM DESIGN/CONFIGURATION PREVENTS, INTERFERES WITH, OR LIMITS OPERATOR PERFORMANCE.
- PROVIDE DEPENDABLE BASIS FOR ASSESSMENT OF OPERATIONAL IMPACT, IF ANY.

ERROR RATES

HOW:
- OBSERVATION
- SUBJECTIVE
- OBJECTIVE
  - 1553 BUS
  - SIGNAL DETECTION

WHY:
- IDENTIFY OPERATOR/EQUIPMENT DEFICIENCIES CAUSING ERRORS IN OPERATIONAL ENVIRONMENT

DISPLAY-TASK ANALYSIS

HOW:
- DISPLAY FORMATS & CONTROLS
- OBSERVATION
- VIDEO
- SUBJECTIVE

WHY:
- DETERMINE IF THE DISPLAY FORMATS AND PRESENTATION SEQUENCES ARE ADEQUATE FOR THE OPERATIONAL TASK.

ENVIRONMENTAL EVALUATION

HOW:
- PHYSICAL MEASURES
  - ACOUSTICAL
  - LIGHTING
  - HUMIDITY
  - AIR FLOW
  - COOLING/HEATING

WHY:
- OPERATOR COMFORT AS MAY BE INDICATED BY QUESTIONNAIRE RESPONSES
- AFFECTS OPERATOR PERFORMANCE

SMALL GROUP ANALYSIS

HOW:
- COMMUNICATIONS STRUCTURE - WHO TALKS TO WHOM (CENTRALITY ANALYSIS)
- COMMUNICATIONS RATE - FREQUENCY, LENGTH, PROPORTION OF TIME
- CRITICAL LINK ANALYSIS - OVERLOADS, BOTTLE NECKS, TYPE OF INFO
- GROUP EFFECTIVENESS - DECISION-MAKING BIASES

WHY:
- DETERMINE GROUP EFFECTIVENESS IN INFORMATION AND DECISION-MAKING

BEHAVIORAL ANALYSIS (CRITICAL INCIDENT)

HOW:
- ANALYSIS OF CAUSE AND EFFECT OF CRITICAL INCIDENT INVOLVING OPERATOR FATIGUE, WORKLOAD AND STRESS

WHY:
- CRITICAL INCIDENT ADVERSELY AFFECTS SYSTEM PERFORMANCE

T&E PERFORMANCE MEASUREMENT REQUIREMENTS

- SPECIFIC TASK STANDARDS OR PARAMETERS
- ACCEPTED EVALUATION METHODOLOGY

ATTACHMENT U

SELECTING PERFORMANCE MEASURES: SOME PRACTICE

AND SOME THEORY (APA/21)

SOME PRACTICE

- 22 OPERATIONAL SYSTEM TESTS IN LAST THREE YEARS
- IN EVERY ONE, PART OF PROBLEM WAS "MEASUREMENT"
- SOME GENERAL CHARACTERISTICS:

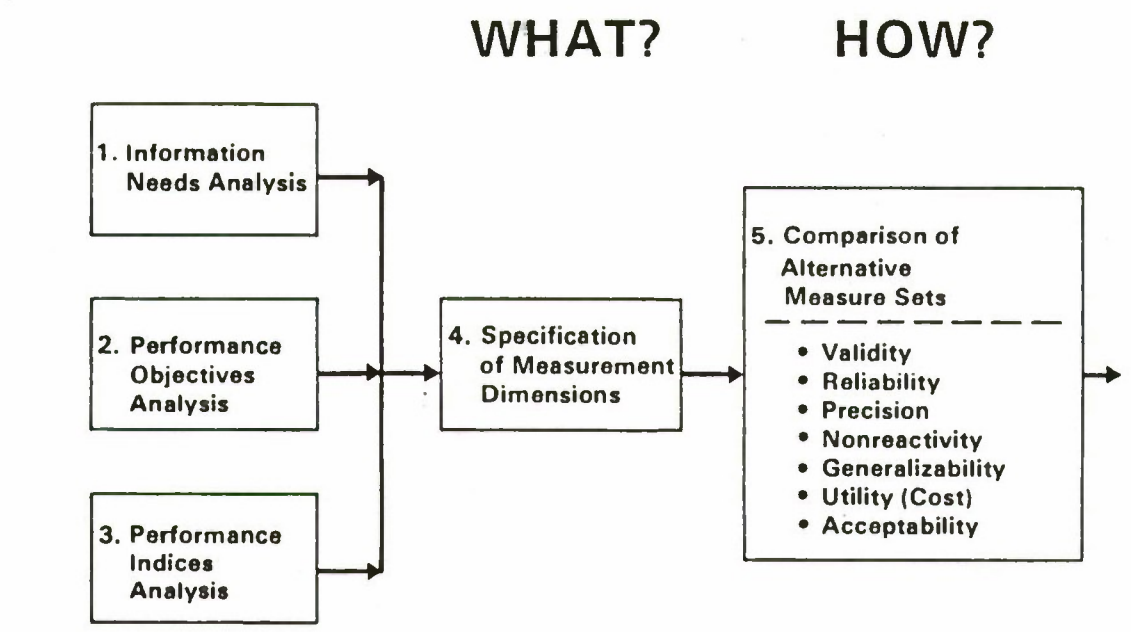
(1.) Every test has been different
(2.) Always severe time and cost constraints
(3.) Simple, composite, measures desired
(4.) Evaluation, not diagnosis, stressed
(5.) Measurement "Acceptability"
(6.) Strong demand for "Expert Judgement"
(7.) Negativity toward Human Performance Measurement
(8.) Training of Testers and Evaluators
(9.) Instrumentation always different
(10.) Automated, Computer-Aided, System PM

- WHAT DO WE DO IN PRACTICE? MUDDLE THROUGH

SOME THEORY

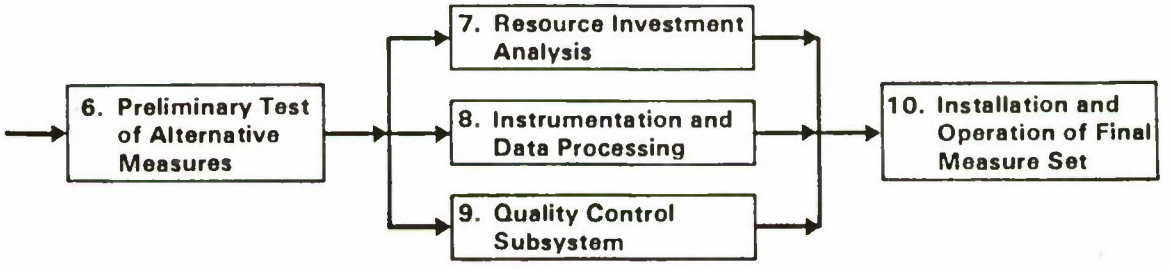
- HOW CAN WE IMPROVE PERFORMANCE MEASUREMENT?
- IF WE HAVE QUANTITATIVE THEORY . . . .
  - THE MEASURE SETS ARE GIVEN
- IF WE DON'T, NEED A METHOD . . . .
  - GOING TO TRY ONE ON YOU
- A 10-STEP MODEL FOR PERFORMANCE MEASUREMENT DEVELOPMENT
  - PROBABLY NO ONE WILL USE IT
  - BUT, IF PEOPLE WILL START THINKING
- THE BASIC QUESTION:
  - WHAT DO YOU WANT TO KNOW?

A MODEL FOR PERFORMANCE MEASUREMENT DEVELOPMENT



A MODEL FOR PERFORMANCE MEASUREMENT DEVELOPMENT

(continued)



ATTACHMENT V

IMPLEMENTATION EFFORTS FOR MANPRINT

MANPRINT

MANPRINT IN THE REAL WORLD: SIX WAYS FOR A LOGISTICIAN TO EMBARRASS A HMPT SPECIALIST

JUDAH KATZNELSON
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SCIENCES

MANPRINT IN THE REAL WORLD: SIX WAYS FOR A LOGISTICIAN TO EMBARRASS A HMPT SPECIALIST

For the past several years, I have been collecting a list. The list represents all the frequently well-intentioned, but usually critical, comments that we, in the people business, encounter when we try to introduce Manpower and Personnel Integration (MANPRINT) elements i.e., human engineering, manpower, personnel, training (HMPT) into new design environments. So far, I've gotten up to six - feel free to add to my list. My purposes for writing this paper are a) to communicate why I believe we have matured as a discipline to the point where we don't need to feel embarrassed or take a defensive posture; and b) share some "lessons learned" from the field where I interacted with people representing some of the key disciplines in the weapons systems acquisition process. The Light Helicopter-Experimental (LHX) was the first time that a major Army weapon system acquisition was to be procured based upon a performance-driven Request for Proposal (RFP). No longer was the government going to dictate a detailed "how to". The concept was to have the government notify industry of the required performance goals and let the contractor use his own creativity to design a weapon system that will meet the performance standards.

A few months ago, I had the opportunity to serve on the Source Selection Evaluation Board (SSEB) for the LHX engine. My specific assignment was to head the MANPRINT evaluation group which reported to the Integrated Logistics Support (ILS) evaluation section. This was the first time that a MANPRINT specification had been issued by the Army to industry. Many of my comments are geared towards an analysis of what happened when MANPRINT and the logisticians met.

Up to this point, our experience with MANPRINT had been on a conceptual level. With the arrival of LHX, this concept was translated into reality. Like other translations, some things translate more easily than others and although we anticipated conceptual challenges, we found problems of acceptance instead. Over the four months that the SSEB convened, the logisticians certainly had ample opportunity to challenge the conceptual foundaton of MANPRINT. They didn't. I believe that this lack of sustainable objections, in effect, validates the MANPRINT concepts. MANPRINT was asking the ILS community to take a different look at themselves. Call it resistance to change, culture shock, or any other name, the potential for problems was there and had to be dealt with. The key to the problem is to understand the true nature of resistance. Actually, what people resist is usually not technical change, but social change - the change in their human relationships that generally accompany technical change. Resistance is usually created because of certain blind spots and attitudes which people have as a result of their preoccupation with the technical aspects of new ideas. It is created by the way those affected by the change <u>think</u> it will alter their established relationships in the organization. In any case the list of embarrassing comments awaits our attention.

1. MANPRINT IS NOTHING MORE THAN THE APPLICATION OF COMMON SENSE.

To those that believe MANPRINT is nothing more than the application of common sense, it follows that almost anyone can do it. This thought showed itself on both the organizational and individual level. Organizationally, one of the bidders for the LHX engine proposed placing MANPRINT as a subelement of "Service Engineering". Individually, none of the personnel chosen by the three bidders to lead the logistics effort showed any HMPT experience or training. One bidder, obviously sensitive to the increased emphasis on the MANPRINT program, proposed to use a "MANPRINT Coordinator". Unfortunately, the person nominated to fill this position had a Bachelor of Science degree in Drama and no HMPT background.

There are basically two different ways to deal with this comment. First, it can be argued that it is true - that a certain amount of work in MANPRINT does reflect the application of common sense. Nevertheless, somehow without the impact of MANPRINT and HMPT specialists, this kind of common sense seems to be overlooked often. Everyone has his own favorite example of this phenomenon. Everyone would probably agree that it would be illogical for the military to develop a manned weapon system composed of hardware and software for which someone in headquarters will somehow find the right people to operate and maintain it. Common sense tells us that one cannot ignore the human element that way without effecting system performance. HMPT issues must be considered from the early design stages. Unfortunately, this very thing happens far too often. The principal defect in the process is that new developments are viewed as systems-to-be manned instead of manned systems.

The second perspective for dealing with this issue argues that almost everything is common sense when you view it with hindsight. Let me present a quote:

> "Outside of the proven impossible, there probably can be found . . . no field where so much inventive seed has been sown with so little return as in the attempts of man to fly successfully through the air. . . . It may be truly said that, so far as the hope of a commercial solution of the problem is concerned, man is today no nearer to fulfillment than he was ages ago when he first dreamed of flying through the air. . . . A calm survey of certain natural phenomena leads the engineer to pronounce all confident prophecies at this time for future success as wholly unwarranted, if not absurd."

This quotation was authored by Rear Admiral Melville, then Engineering-Chief of the U.S. Navy in 1901, two years before the first successful flight at Kitty Hawk.

It is certainly true that after the fact it is easy to make almost any result appear to be common sense and to put those predictions on a

quantitative basis. The goal of much of MANPRINT is to predict what will become common sense after the fact.

Yes, some HMPT principles are common sense and other become common sense with hindsight, but in all of these cases, it takes a professional to understand how and when such common sensical knowledge applies.

2. THE STUFF YOU DO IS TOO ABSTRACT TO BE USEFUL TO ME.

I frequently heard the criticism that "MANPRINT stuff" is too "researchy". I don't think one can expect everything to be useful immediately. It certainly would have been nice if MANPRINT was fully developed and provided a "recipe book" to follow that would insure adequate emphasis on the operator/maintainer of the system. Although many players in the MANPRINT community are actively working towards that goal, we are not there yet. One purpose of research is to advance the state of knowledge. This is a gradual process. The individual who makes this comment needs to understand that it takes time to see MANPRINT issues pay off. Those in the logistics community should keep this in mind. On the other hand, we in the HMPT community need to realize that logisticians have immediate problems in the 9-5 working world that need immediate attention.

Because MANPRINT is not yet a fully developed technical program, industry was somewhat mystified by its requirements. This uncertainty manifested itself in the contractor's proposals. It was interesting to note that some of the bidders chose to use non-binding contractual/legal terms when dealing with MANPRINT issues. Whereas the remainder of the proposal used the contractually binding term "shall", the MANPRINT section used the term "will". The bidders were wary of being held contractually responsible for something they did not fully understand. We, as government employees, must make every effort not only to de-mystify MANPRINT, but to insure that the appropriately binding terms are used. Like the government, contractors also would have appreciated the security of a "recipe book" that would have provided guidance. In the absence of such a guide, it is a good idea to provide contractors with a listing of the key points of contact thus enabling them to talk to the MANPRINT players before they formulate their MANPRINT plans. This will enable contractors to begin the familiarization process that can change their perception of MANPRINT from the abstract to the real world.

3. THAT'S A GREAT CONCEPT, BUT YOU JUST CAN'T DO IT THAT WAY.

While serving on the SSEB, I had the opportunity to present a number of briefings on MANPRINT's approach to the LSA/LSAR process, the concept of "skill" and the use of MOSs to set MPT requirements. The audiences listened attentively and asked pertinent questions. The discussions always started with abstract philosophy and gradually shifted to practical applications. I was told how interesting and sensible MANPRINT was, and yet, time after time, I was told that it was best just to conduct business as usual. "There was no need to propose new ways to ascertain HMPT requirements." After all, the "LSA/LSAR process already addresses the MANPRINT elements", "skill is known and stable over time", and "just use the MOS to determine MPT limitations."

I was told that these approaches/definitions had worked in the past, everyone was familiar with them, and changing anything would be costly and counterproductive. A lot of resistance can be hidden under the statement of "that's a great concept, but you just can't do it that way."

This is indeed a frequent criticism of the MANPRINT specialist working in an engineering environment, but let the logistician be patient with us. Any specialist worth his salt will learn rapidly what the technical, engineering design, cost and logistical constraints are. Our field depends on the ability to make trade-offs between MANPRINT issues on the one hand and technical, design, cost and logistical constraints on the other.

The logistician will also want to be careful when he uses this gambit that he is not exposing his own flank. MANPRINT specialists can also say, "that's a fine design, but the operator/maintainer just won't use it that way".

Finially, it is ironic that this phrase was used by some to resist MANPRINT. The RFP procurement process presented me with the opportunity to use this statement to show members of the Project Managers Office (PMO) and the SSEB how a great concept (for example - a stream-lined, intergrated RFP) can prove detrimental to the achievement of your goals (in this case - to shorten the procurement process and to produce an RFP that will convey clearly the MANPRINT requirements). The LHX Engine RFP (written by the PMO) had three sections that dealt with MANPRINT: 1) Section L - Instructions, Conditions and Notices to Offerors, 2) Section M - Evaluation Factors for Award and 3) Attachment 1 - System Specification. Section L had the word MANPRINT as a paragraph title with no supporting prose. Section M stated that "the MANPRINT factor will be evaluated based on the adequacy, completeness and level of detail provided in describing how the offeror intends to fulfill the stated System Specification requirements. Attachment 1 not only did not single out any MANPRINT specifications, but the government's other system specifications more often than not violated the very MANPRINT principles for which the contractor should be held accountable. It is easy to understand why the offerors had trouble writing coherent proposals on a topic which had no requirements. As they went from the RFP to the Evaluation Factors to the System Specifications, they were being led along a path that led nowhere. While I was assigned to the board, a significant amount of my time was spent trying to rectify this situation. Numerous times barriers were placed in the way of obtaining an RFP containing suitable MANPRINT requirements. The MANPRINT evaluation group proposed to remedy the situation by preparing an RFP amendment containing MANPRINT requirements. Three versions of the amendment was submitted to SSEB management in an effort to produce an amendment that was acceptable to them. Three times the RFP amendment was re-drafted to comply with their special tailoring guidance. Three times these proposals were rejected. We gave MANPRINT briefings, prepared specially tailored questions for offerors to elicit suitable technical responses (which could be evaluated), and worked with other technical specialty programs (e.g., LSAR, HFE) to incorporate MANPRINT concerns. (While upper management was sometimes resistant to change, LSAR & HFE are two examples where once they gained some familiarity with

MANPRINT, lower level technicians assisted in integrating MANPRINT concerns into the weapon systems acquisition process). When these efforts produced less-than-optimum responses by offerors, still another request for an RFP amendment was made. By carefully marshalling our arguments and showing the technical deficits caused by the present course, the MANPRINT evaluation group was able to convince three levels of SSEB management to make an eleventh hour change of direction and include in an RFP amendment the basic substance of MANPRINT. A stream-lined, integrated RFP is a good idea. However, in this case, the integration effort almost didn't work. It was only by persistance that the barriers were broken.

4. MANPRINT ISN'T THAT IMPORTANT - PEOPLE ARE ADAPTIVE

While I have heard this point argued many times, I shouldn't have to belabor it with this audience. It's a well-known fact that people using equipment designed with integrated HMPT elements are more resistant to errors. It is true that people are adaptable and that, after experience with a system, they have more difficulty reporting on its shortcomings, but that doesn't mean that their efficiency and effectiveness is not reduced.

The education of HMPT specialists wouldn't be complete if they were not exposed to the classic story of an ingenious experiment reportedly conducted at the Bell Telephone Laboratory during World War II:

> The telephone company was concerned about the ways to save copper (a scarce commodity during war) and one use of copper was in the cable connecting the telephone handset to the table-top set. The experimental question was, "How long does a telephone cord need to be?" The investigator identified a series of test telephones around the laboratory. Each night, they went to those telephones, reduced the length of the line cord by one inch and replaced the telephone in its normal position on the desk. They then designated a special telephone operator to receive complaints about the telephone. Day by day, the line cords got shorter, and one by one, their users began to complain to the special operator. When the line cord had reached a given length, about half of the participants had complained, and this process continued until the line cord was only a few inches long. There remained one person who still had not complained. The investigators decided to check up on him. One of them visited his office while the second called him on the telephone. Sure enough, when the telephone rang, he leaned over his desk so that his ear could reach the handset, and he answered the phone in a very awkward manner indeed. When asked later if there was anything

funny about his telephone, he said, "Oh, the line cord is a little short, but that doesn't concern me."

As I said, people are very adaptive, but that doesn't justify poor design, training or performance.

5. AFTER I GET THE LOGISTICS SYSTEM WORKING, THEN I'LL LOOK INTO MANPRINT ISSUES . . . IF I HAVE ANY TIME LEFT.

This assertion is all too often offered. We (in the MANPRINT community) are plagued with being left out, or with getting in after the major decisions have been made. By getting in early, we can have orders of magnitude more influence on system performance; but, when getting in late, our influence is reduced to percentage points. Getting in early depends on management, and that leads me back to the RFP.

It is not possible to over-stress the importance of the RFP. The draft RFP for the LHX engine was 511 pages. At the direction of the Under Secretary of the Army, the RFP was reduced 75% to a total of 144 pages to make it more manageable. Unfortunately, crucial details were cut as well. MANPRINT's original input went from 12 sentences to 1 word. MANPRINT appeared as a paragraph title, but none of the prose under the title had anything to do with MANPRINT. No longer were there any MANPRINT requirements in the government's RFP. (Other sections experienced a similar fate - i.e., the LSA/LSAR Provisioning input was reduced from 33 pages to 1 paragraph, the HFE section experienced a 20% reduction, etc.).

In attempting to reduce the bulk of the RFP and because time was not allowed for coordination with the suppliers of the original submissions, the prose reductions were made by members of the PMO who possessed inadequate knowledge of these disciplines and could not appreciate the full ramifications of their editorial changes. Theirs was simply an honest attempt to comply with the guidance they received. Not surprisingly, the topic areas that they were least familiar with suffered the most. Some of the problems encountered by the MANPRINT evaluation group with this RFP could have been minimized or avoided if the time for proper coordination with subject matter experts had been taken at the beginning of the process before multiple changes were made.

This management approach of trying to fine-tune MANPRINT issues later leads us to the next issue.

6. DON'T WORRY - WE CAN ALWAYS MODIFY THE RFP AND/OR NEGOTIATE A CHANGE WHILE WE'RE EVALUATING THE PROPOSALS.

It sounds so logical . . . simply modify the RFP . . . why delay the process? Certainly it is appropriate to modify a RFP where a change will benefit the government. The problem arises in a situation where the various disciplines have differing opinions as to what will benefit the government. For the LHX engine, the logisticians were only the first group that had to be convinced that MANPRINT concerns needed to be in the RFP and were too important to leave to the vagueness of the after-contract-award negotiation. By showing SSEB management the

technical deficits caused by the present RFP, management was convinced of the benefits of change. We have already discussed the sequence of events that led to an RFP amendment concerning MANPRINT requirements (see item #3, page 4). Once this amendment was accomplished, the legal and contracting people needed to be persuaded as well.

At this point, we should guard against complacency. Keep in mind the criticality of the RFP. Just when you think you have all the elements under control, "Murphy" strikes. To understand this situation, you must understand the document structure. The government documentation consists of the RFP, an Evaluation Plan and the System Specification. Parts of industry's response were proposals for System Specifications, an Integrated Logistics Support Plan, Human Factors Plan, MANPRINT Plan, etc. Industry's System Specification was a general statement of what the contractor would deliver and was not generally distributed to all of the government evaluators. The government 's legal advisor (Murphy in disguise), notified the SSEB that the contractor's System Specification takes contractual precedence over the individual technical plans for proposal evaluation purposes. The problem occurs when industry's System Specification "parrots back" the RFP requirements, but their technical plans exclude the specific items or details required to satisfactorily complete the entire System Specification requirement. Due to this contractal precedence, the contractor's technical plans can contain numerous weak points, be of marginal value, and yet receive a satisfactory rating. It is only when the proposal contains an inadequacy or omission that will preclude the contractor from meeting program objectives that we were allowed to rate a proposal as unsatisfactory.

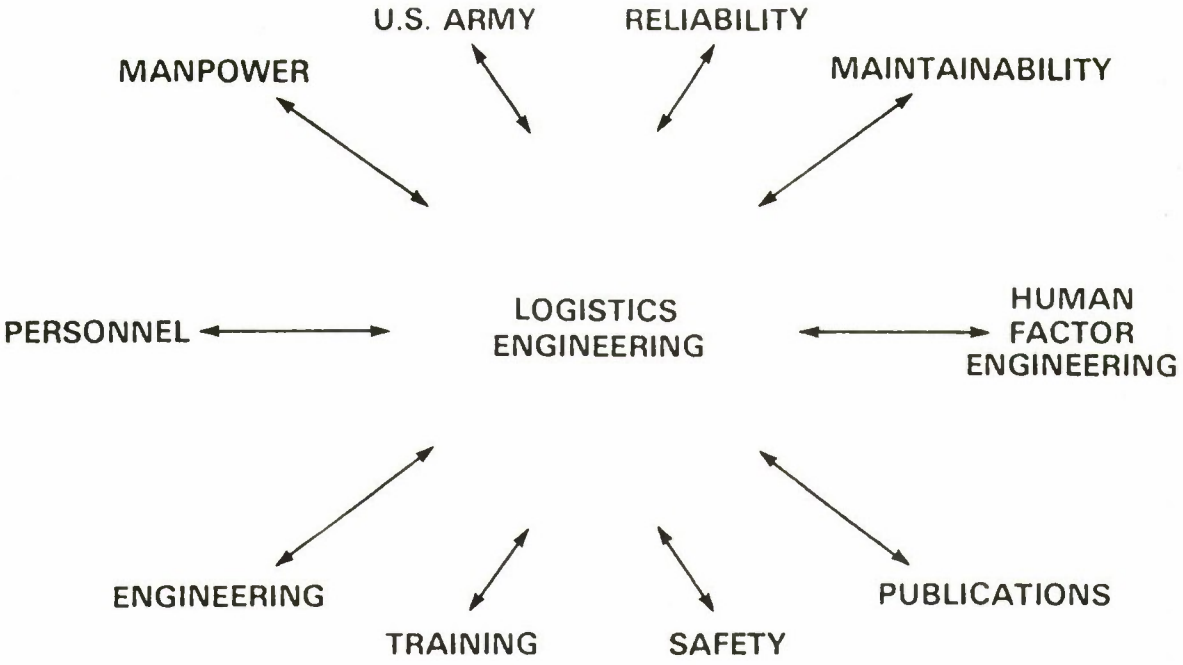
Confusing isn't it? Here's an example of the government's legal advisors helping industry meet the letter of the law rather than the intent. Somehow I don't believe that this is what Congress had in mind. Looking at it another way, the offeror is judged satisfactory if he states that he merely intends to meet the requirements. This is analogous to hiring someone who agrees to meet the requirements of a job description and yet not being allowed to evaluate his training, education, experience, etc.

The fix for this predicament is to make the offer's System Specification an ungraded requirement that must be met prior to the evaluation of technical plans. That is, if the System Specification is not responsive to the requirements of the RFP, the detailed plans are not evaluated.

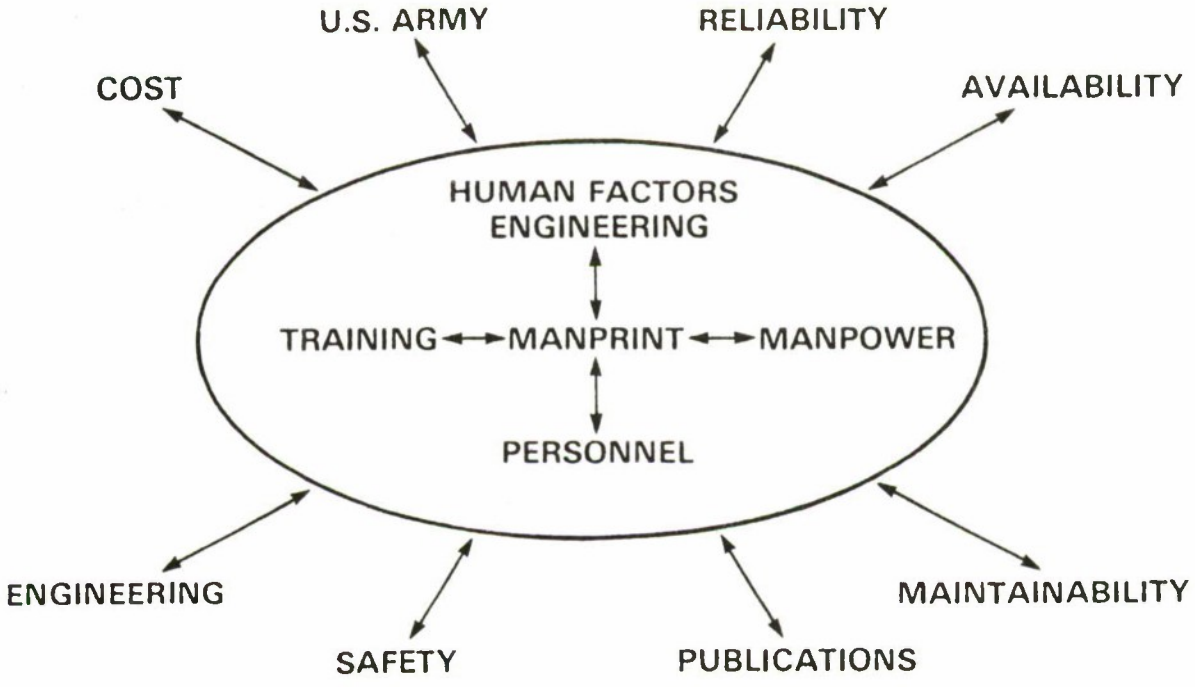
So much for the six potential embarrassment and lessons learned. I hope I have convinced you that we need no longer be defensive about them. Although we were curious as to whether MANPRINT would attract any conceptual challenges, none were offered. Problems of acceptance and resistance to change by some were the only obstacles we encountered. The absence of conceptual disagreements validates the underpinnings of the MANPRINT program.In my view, we are currently in a phase where HMPT work is receiving increasing acceptance. Military budgets for human resources research and development continue to rise.

In short, I have never been more enthusiastic about MANPRINT issues and it's potential for serving as one interface between technology and society. Some of the relatively young logisticians were willing to

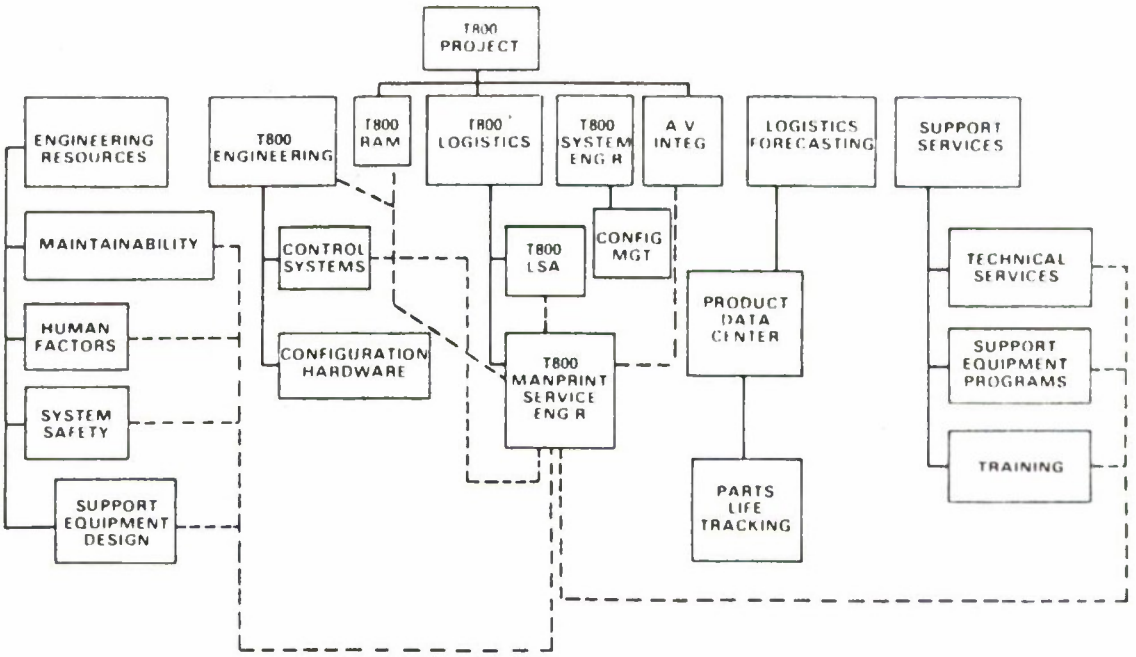
listen. Some were willing to take a chance and learn. We need to teach them. In time, the others will follow. With experience and lessons learned as a basic foundation, we can achieve realistically stated system performance goals during system development while reducing manpower and personnel demands. I hope you share my enthusiasm.



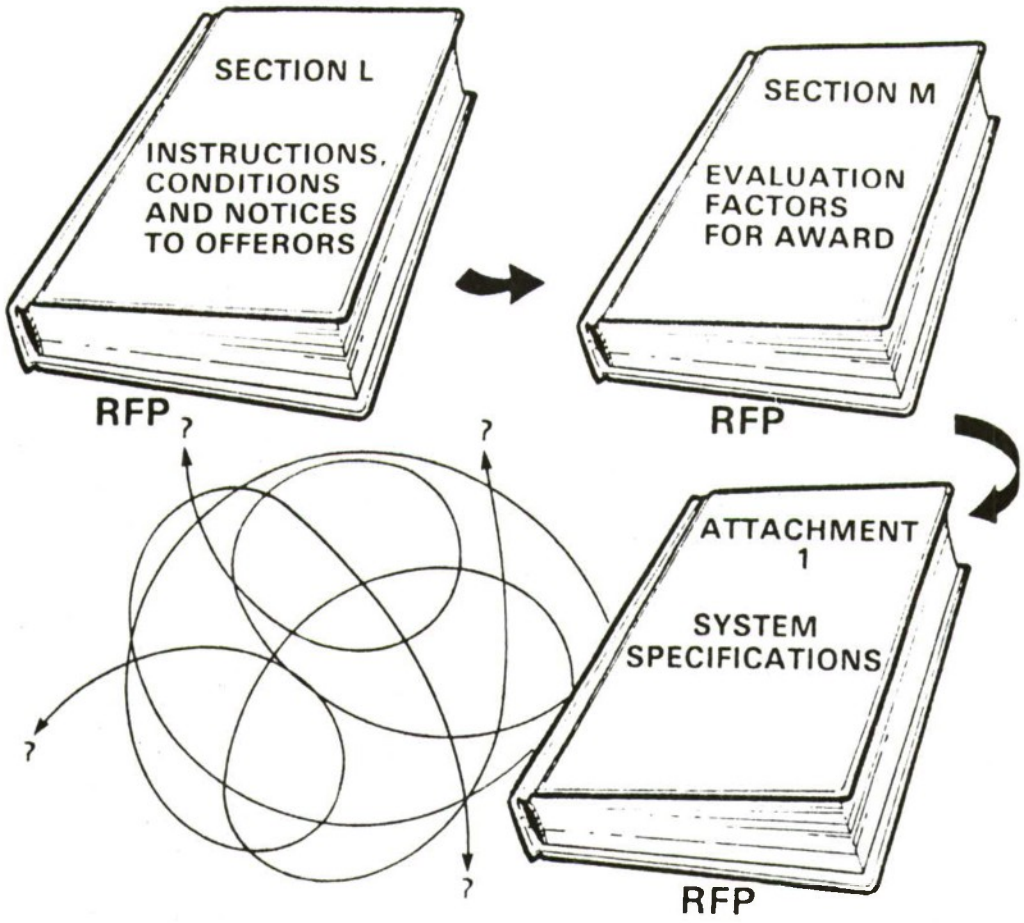
THEIR VIEW...

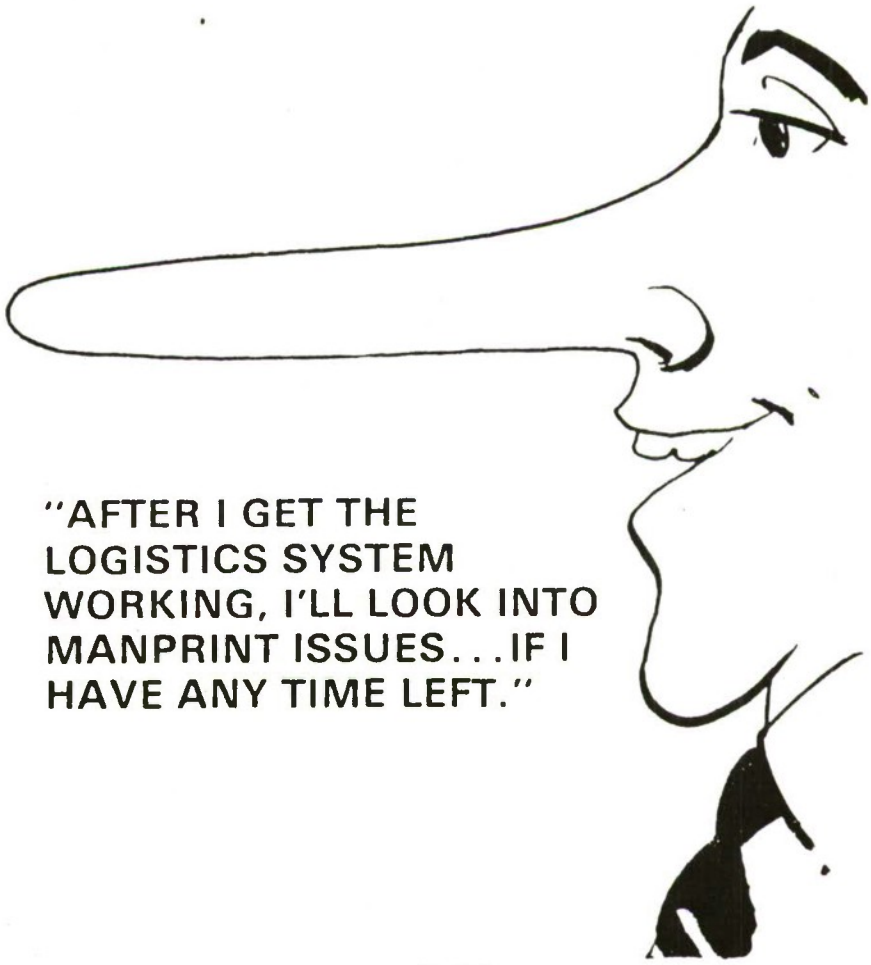


OUR VIEW...



Manprint Coordinator Responsible for implementing the T800 MANPRINT Program Plan, which includes coordinating all activities and integrating human resource requirements for manpower quantity, personnel quality, and skill training requirements into the T800 design.	Two years experience at [redacted] in logistics field. Three years industry experience in technical writing, where he developed work package programs for military applications. In addition Mr. [redacted] has four years of Marine Corps experience in maintenance and training. He is currently an Arizona Army National Guard rotary wing pilot. B.S. Acting and Directing: Northern Arizona University


SECTION L
INSTRUCTIONS, CONDITIONS AND NOTICES TO OFFERORS
RFP
SECTION M
EVALUATION FACTORS FOR AWARD
RFP
ATTACHMENT 1
SYSTEM SPECIFICATIONS
RFP
?
?
?
?


"AFTER I GET THE LOGISTICS SYSTEM WORKING, I'LL LOOK INTO MANPRINT ISSUES...IF I HAVE ANY TIME LEFT."

ACQUISITION DOCUMENTS....

GOVERNMENT		INDUSTRY
REQUEST FOR PROPOSAL EVALUATION FACTORS SYSTEM SPECIFICATIONS	≠	SYSTEM SPECIFICATIONS TECHNICAL PLANS – INTEGRATED LOGISTICS SUPPORT – MANPRINT – HUMAN FACTORS – ETC.

ATTACHMENT W

STATE-OF-THE-ART IN AI/ES, DECISION AIDING AND AUGMENTATION FOR ADVANCED MILITARY SYSTEMS

ARTIFICIAL INTELLIGENCE and EXPERT SYSTEMS
FOR
ADVANCED MILITARY and SPACE SYSTEMS

THOMAS M. COOK
Martin Marietta
Denver Aerospace

PURPOSE

TO PROVIDE A SUMMARY OF CURRENT " STATE-OF-THE-ART" REGARDING THE APPLICATION OF AI, EXPERTS SYSTEMS AND "SMART" DECISION AIDS TO DOD and NASA DOMAINS.

TOPICS TO BE COVERED INCLUDE:

- A BRIEF DESCRIPTION OF THE TECHNOLOGY AREAS
- TYPICAL APPLICATION AREAS
- CURRENT RESOURCES (e.g., Personnel, HW, SW, etc.)
- CURRENT STATE OF TECHNOLOGY READINESS
- FUTURE DIRECTIONS & CHALLENGES

TECHNOLOGY AREAS

ARTIFICIAL INTELLIGENCE: The attempt to produce computer systems (i.e., HW, SW, I/O devices, etc. which can perform complex tasks requiring reasoning and perception. That is, to produce machines which can " act intelligently" , to include the enhancement of human intelligence.

RELATED AREAS:

EXPERT SYSTEMS
NATURAL LANGUAGE UNDERSTANDING
IMAGE UNDERSTANDING
INTELLIGENT ROBOTICS
ADVANCED COMPUTER ARCHITECTURES (E.G., Butterfly, Connection Machine, etc.)
INTELLIGENT DECISION AIDS

EXPERT SYSTEMS: Computer programs (and associated interfaces) which are designed for high performance . That is, a degree of functionality and and efficiency comparable with or better than human experts.

TYPICAL APPLICATION AREAS FOR AI and EXPERT SYSTEMS

DOD APPLICATIONS

DARPA STRATEGIC COMPUTING PROGRAM

- Autonomous Land Vehicle
- Battle management (C3I, Staff Planning, etc.)
- Pilots Associate

GENERIC APPLICATIONS (e.g., Army R&D Plan)

- Human/ Equipment Interface Aids
- Planning and Monitoring Aids
- Expert Advisors
- Data Access and Assimilation Aids
- Support Systems
- Situation Assessment Systems
- System Controllers
- Information Collectors
- Training & Instruction (e.g., ICAI)

NASA APPLICATIONS

SPACE STATION PROGRAM

- System Health & Status Monitoring
- Fault Detection, Isolation and Control
- Failure Prediction (e.g., Trend Analysis)
- Resource Management
- On-Orbit Maintenance & Repair Assistance
- Experiment Assistance
- Crew Training
- Launch Processing & Status
- Mission Planning
- Operations Control

OTHER

- Satellite Monitoring and Control
- Intelligent Robotic Planners
- Intelligent Autonomous Spacecraft

RESOURCES

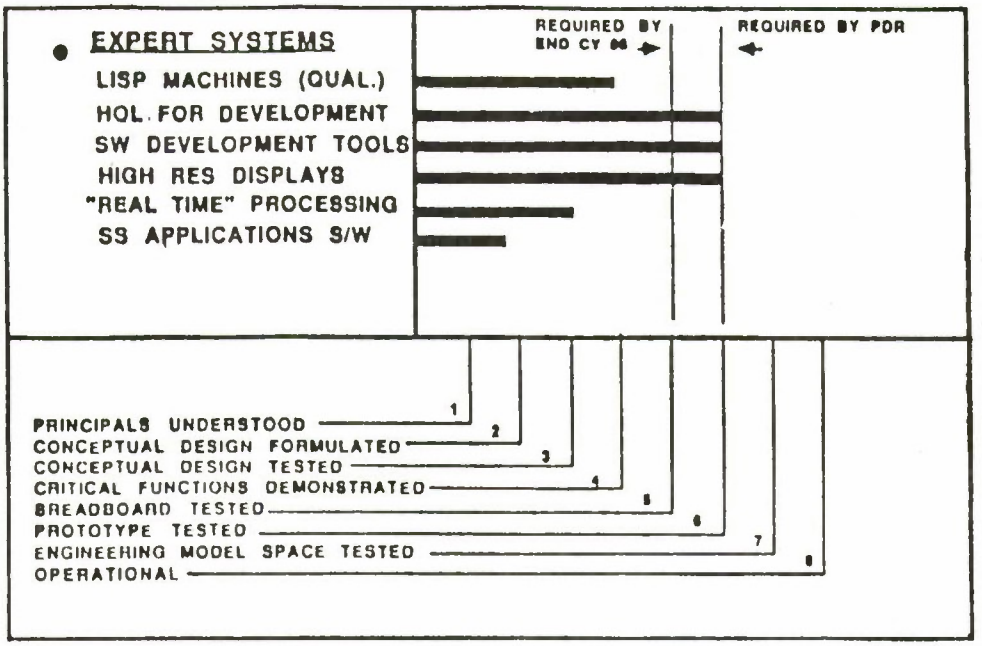
Personnel

- Shortage of skilled Knowledge Engineers (Computer scientists, psychologists, HFEs, other ?)
- Difficulty isolating, capturing and representing true "expertise"
- Salaries and benefits (or, can DOD and NASA "Grow their own" ?)

Hardware & Software Environments

- AI (e.g., LISP) development machines available and DECREASING in size and price while INCREASING significantly in speed and flexibility.
- AI application machines (e.g., LISP machine on a chip) available within 1-3 years (radition hardened, SEU immune, etc.).
- Powerful software development tools available for all levels of application, to include intelligent graphics (e.g., ART, KEE, OPS5, etc.).

TECHNOLOGY READINESS ASSESSMENT



CURRENT CHALLENGES & *FUTURE DIRECTIONS*

ARTIFICIAL INTELLIGENCE

- Natural Language Understanding
- Object/ Pattern Recognition
- Machine "Learning"
- Measures of Confidence re: Autonomy

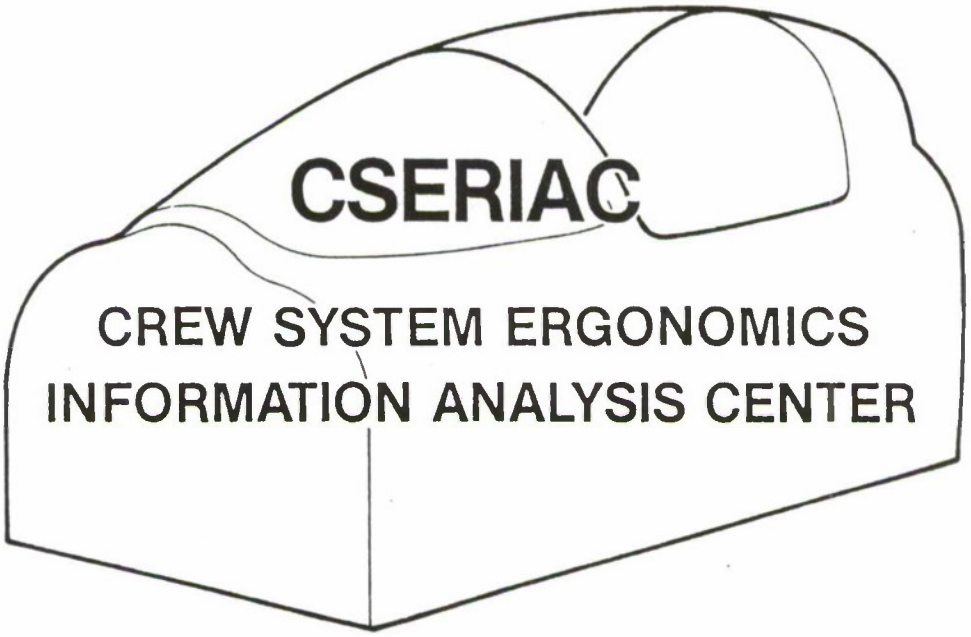
EXPERT SYSTEMS (a series of questions)

- Appropriate role for ES
- Performance Requirements
- Measures of Performance
- Nature of "Expertise"
- Access to Experts
- Knowledge Representation
- Verification & Validation Methodology

ATTACHMENT X

CREW SYSTEM ERGONOMICS INFORMATION

ANALYSIS CENTER (CSERIAC)


CSERIAC
CREW SYSTEM ERGONOMICS
INFORMATION ANALYSIS CENTER

DEFINITION

ERGONOMICS

INTEGRATIVE DISCIPLINE DEVOTED TO UNDERSTANDING AND QUANTIFYING HUMAN PHYSIOLOGICAL AND BEHAVIORAL INTERACTION WITH EQUIPMENT AND SYSTEMS

BACKGROUND

- MUCH PERTINENT ERGONOMICS DATA EXIST
- INFORMATION IS WIDELY DISPERSED AND NOT READILY ACCESSIBLE
- RESPONSIVE DoD FOCAL POINTS FOR UP-TO-DATE ERGONOMICS DATA ARE NEEDED

PROPOSED

SHORT TERM:

- AAMRL HOSTS DoD INFORMATION ANALYSIS CENTER FOCUSED ON CREW SYSTEM ERGONOMICS FOR MILITARY AIRCRAFT AND SPACE VEHICLES

LONG TERM:

- **CSERIAC** PROVIDES MODEL AND EXPERIENCE BASE TO SUPPORT DEVELOPMENT OF OTHER SPECIALIZED **HF IACs** HOSTED BY DoD AGENCIES

FUNCTIONS AND SERVICES

- **RAPID** EXPERT CONSULTATION AND SUPPORT
- AUTHOR COMPENDIUMS/HANDBOOKS OF SELECTED ERGONOMICS DATA
- PROBLEM-SOLVING AND ANALYSIS
- **MIL-STANDARDS** AND **SPECIFICATIONS**
- IDENTIFY AND REPORT **HIGH-VALUE TECHNICAL "GAPS"**
- **RECOGNIZED LIAISON** WITH USER COMMUNITIES —PUBLISH NEWSLETTERS AND JOURNALS
- PLANNING AND CONDUCT OF WORKSHOPS, SYMPOSIUMS, SHORT COURSES AND CONFERENCES

DLA/DTIC ADMINISTERED DoD INFORMATION ANALYSIS CENTERS

INFORMATION ANALYSIS CENTER

CHEMICAL PROPULSION INFORMATION AGENCY

DATA AND ANALYSIS CENTER FOR SOFTWARE

INFRARED INFORMATION AND ANALYSIS CENTER

METALS AND CERAMICS INFORMATION CENTER

NONDESTRUCTIVE TESTING INFORMATION ANALYSIS CENTER

RELIABILITY ANALYSIS CENTER

TACTICAL WEAPONS GUIDANCE AND CONTROL INFORMATION ANALYSIS CENTER

THERMOPHYSICAL AND ELECTRONIC PROPERTIES

METAL-MATRIX COMPOSITES INFORMATION ANALYSIS CENTER

MANUFACTURING TECHNOLOGY INFORMATION ANALYSIS CENTER

SURVIVABILITY/VULNERABILITY INFORMATION ANALYSIS CENTER

POTENTIAL USERS

GOVERNMENT

- LABORATORIES
- PM'S & SPO'S
- EVALUATION AGENCIES
- SYSTEMS COMMANDS
- PENTAGON
- LOGISTICS
- INTELLIGENCE
- ADVISORY GROUP FOR AEROSPACE R & D

INDUSTRY

- PRIMES
- CONTROL/DISPLAY CONTRACTORS
- SYSTEMS ANALYSTS
- OPERATION ANALYSTS
- CONSULTANTS
- SUB-CONTRACTORS
- VENDORS
- SOFTWARE DEVELOPERS

SUBJECT DOMAINS

A. DESIGN METHODOLOGY

B. HUMAN PERFORMANCE CHARACTERISTICS

C. INFORMATION DISPLAY INTERFACES

D. MOTOR/CONTROL SYSTEMS CHARACTERISTICS

E. SPECIALIZED DESIGN ISSUES

SUBJECT DOMAINS

A. DESIGN METHODOLOGY
   1. OPERATIONS MODELING
   2. EVALUATION TECHNOLOGY
   3. CAD SYSTEMS
   4. PERFORMANCE MEASUREMENT
   5. COST/PERFORMANCE MODELING

B. HUMAN PERFORMANCE CHARACTERISTICS
   1. SENSORY FACTORS
   2. COGNITIVE FACTORS
   3. MOTOR/CONTROL CHARACTERISTICS
   4. ANTHROPOMETRIC FACTORS

C. INFORMATION DISPLAY INTERFACES
   1. QUALITY METRICS
   2. SPATIAL/TEMPORAL CONFIGURATION
   3. INFORMATION PORTRAYAL

D. MOTOR/CONTROL SYSTEMS CHARACTERISTICS
   1. CONTROL DYNAMICS
   2. PHYSICAL CHARACTERISTICS
   3. CONTROL/DISPLAY INTERACTION

E. SPECIALIZED DESIGN ISSUES
   1. MULTI-CREW INTERACTION
   2. FLIGHT VEHICLE CHARACTERISTICS
   3. OPERATOR CENTERED SYSTEMS
   4. LIFE CYCLE CREW STATION MODIFICATIONS
   5. ENVIRONMENTAL ISSUES

JUSTIFICATION PREPARATION

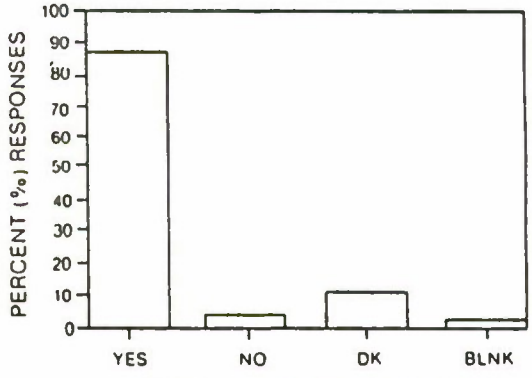
WHO: MONTEREY TECHNOLOGIES
— DR. ROBERT HENNESSY

OBJECTIVE: ASCERTAIN NEED FOR A CENTRAL DoD FOCAL POINT IN CREW STATION ERGONOMICS

TASKS:
— DEFINE USERS
— SURVEY USERS/IACS
— I.D. REQUIRED FUNCTIONS OF CSERIAC
— ESTIMATES OF DIRECT COST RESOURCES

USER'S SURVEY

- OBJECTIVES:
  - —ASCERTAIN NEED
  - —I.D. REQUIRED FUNCTIONS
  - —PROVIDE COST BASIS
- WHO WAS SURVEYED?
  - —3705 QUESTIONNAIRES
  - —27% RETURN
    - DOD: 30%
    - FEDERAL: 4%
    - INDUSTRY/ACAD: 66%



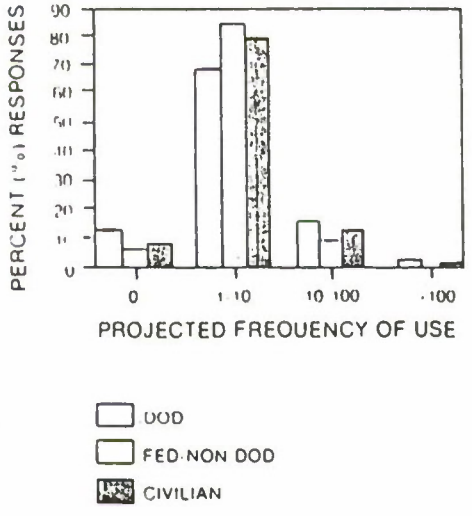
SHOULD THERE BE CSE CENTER?
PERCENT RESPONSES (TOTAL # = 829)

- OF THOSE RESPONDING:
  - —97% USE CREW STATION EGRONOMICS DATA IN THEIR WORK

USERS SURVEY:
(MOST NEEDED PRODUCTS & SERVICES)

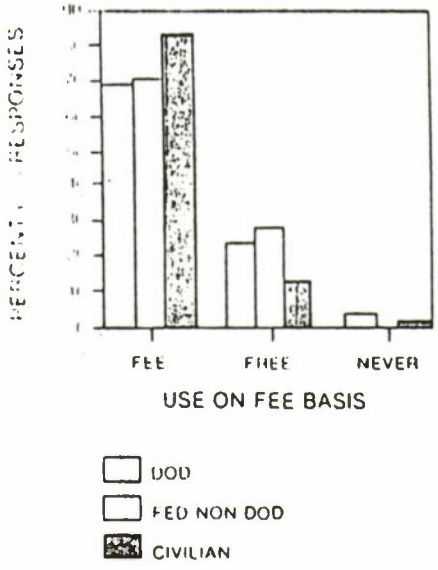
- STATE-OF-THE-ART REVIEWS/TECHNOLOGY ASSESSMENTS
- QUICK RESPONSES TO TECHNICAL INQUIRIES
- CURRENT AWARENESS BULLETINS

USERS SURVEY: FREQUENCY OF USE



- AVERAGE PROJECTED USE:
  ~ 6 REQUESTS PER YEAR
- TOTAL PROJECTED USE BY RESPONDENTS:
  > 4000 REQUESTS PER YEAR

USERS SURVEY: WILLINGNESS TO PAY FOR SERVICES



- 79% ACCEPT A FEE BASIS FOR SERVICE

USERS SURVEY: SUMMARY OF FINDINGS

- 97% USE CREW STATION ERGONOMICS DATA
- 88% SUPPORT ESTABLISHMENT OF CSERIAC
- 79% WILLING TO PAY FOR USE
- HIGH PROJECTED FREQUENCY OF USE

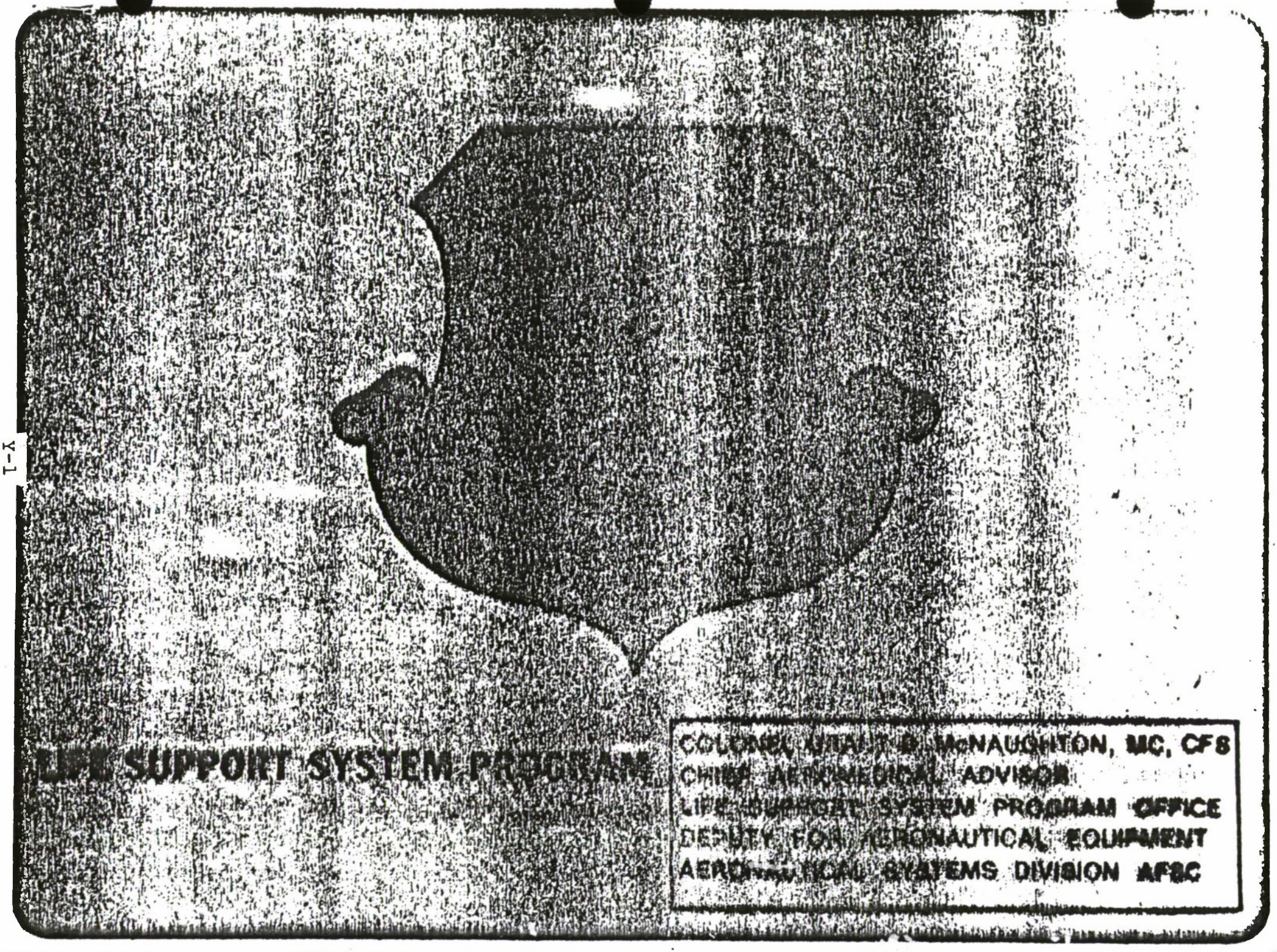
TIMELINES/MILESTONES

— AVOCACY BRIEFINGS THRU CHAIN OF COMMAND	NOV 84 - JUL 85
— BEGIN STUDY TO PREPARE JUSTIFICATION	1 DEC 84
— SURVEY COMPLETE	MAY - JUN 85
— JUSTIFICATION COMPLETE	JUN 85
— FORMAL AVOCACY COMMITMENTS	JUL - AUG 85
— JUSTIFICATION TO OUSDR & D	SEP 85
— SOW TO DLA	JAN 86
— CSERIAC CONTRACT AWARD	JAN 87

ATTACHMENT Y

VISION IN SPATIAL DISORIENTATION AND LOSS OF

AIRCRAFT ATTITUDE OR CONTROL AWARENESS


LIFE SUPPORT SYSTEM PROGRAM
COLONEL (USAF) D. McNAUGHTON, MC, CFS
CHIEF AEROMEDICAL ADVISOR
LIFE SUPPORT SYSTEM PROGRAM OFFICE
DEPUTY FOR AERONAUTICAL EQUIPMENT
AERONAUTICAL SYSTEMS DIVISION AFSC

PURPOSE OF BRIEFING

- PROVIDE INSIGHT ON HOW WE PROCESS INFORMATION
- POINT OUT DESIGN FEATURES THAT IMPEDE VALID INFORMATION ACQUISITION AND APPROPRIATE ACTION
- SPREAD WORD TO USERS
- USE IN MISHAP PREVENTION AND ANALYSIS
- ENLIST YOUR SUPPORT FOR PRACTICAL IMPROVEMENTS IN PRESENT AIRCRAFT
- INSURE THESE ASPECTS BE CONSIDERED IN THE DESIGN OF FUTURE AIRCRAFT, E.G., ATF

POINTS

- ROLE OF VISION IN SDO
- DESIGN FEATURES IMPACTING A/C ATTITUDE AWARENESS
- IMPORTANCE OF ATTITUDE INDICATOR: SIZE/LOCATION
- HUD: NOT AN ATTITUDE INDICATOR
- PATTERN RECOGNITION DISPLAYS

SPATIAL DISORIENTATION

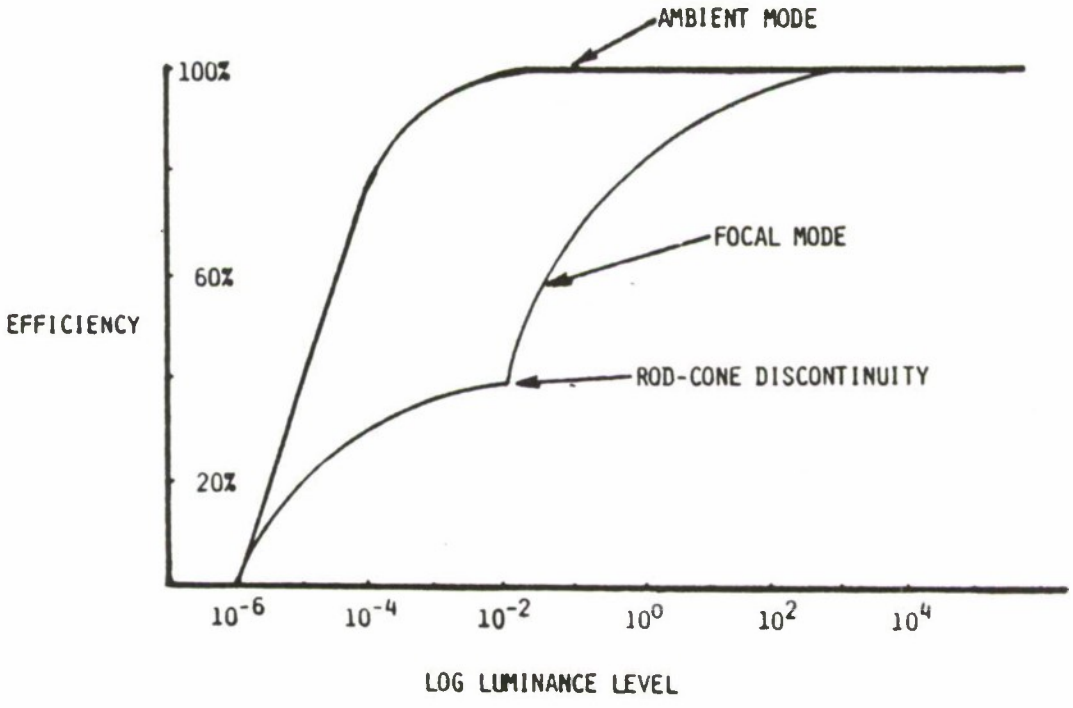
FORMERLY: MISMATCH BETWEEN VISION & BALANCE ORGAN

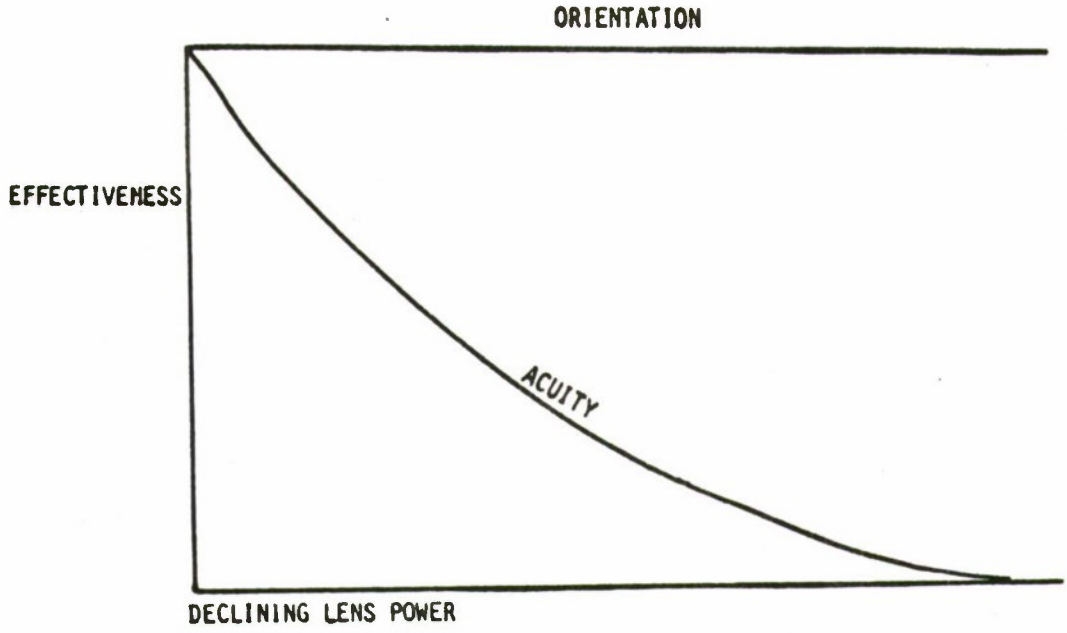
PRESENTLY: MISMATCH BETWEEN VISION & VISION

TWO MODES OF VISUAL PROCESSING

FOCAL	AMBIENT
IDENTIFIES	ORIENTS
OBJECT RECOGNITION	OBJECT QUALITY, QUALITY OF SURROUNDS
DISCRIMINATING	UNCRITICAL
EXCLUSIVELY VISUAL	BALANCE, PROPRIOCEPTION, HEARING
LIGHTING REQUIRED	ANY LIGHTING
RESOLUTION REQUIRED	RESOLUTION UNIMPORTANT
CONSCIOUS ATTENTION	REFLEX LEVEL

VISUAL PROCESSING: TWO-MODE SYSTEM





CONSEQUENCES OF AMBIENT MODE REACTIONS

- DISTRACTION POTENTIAL
- VECTION ILLUSION
- FALSE HORIZON

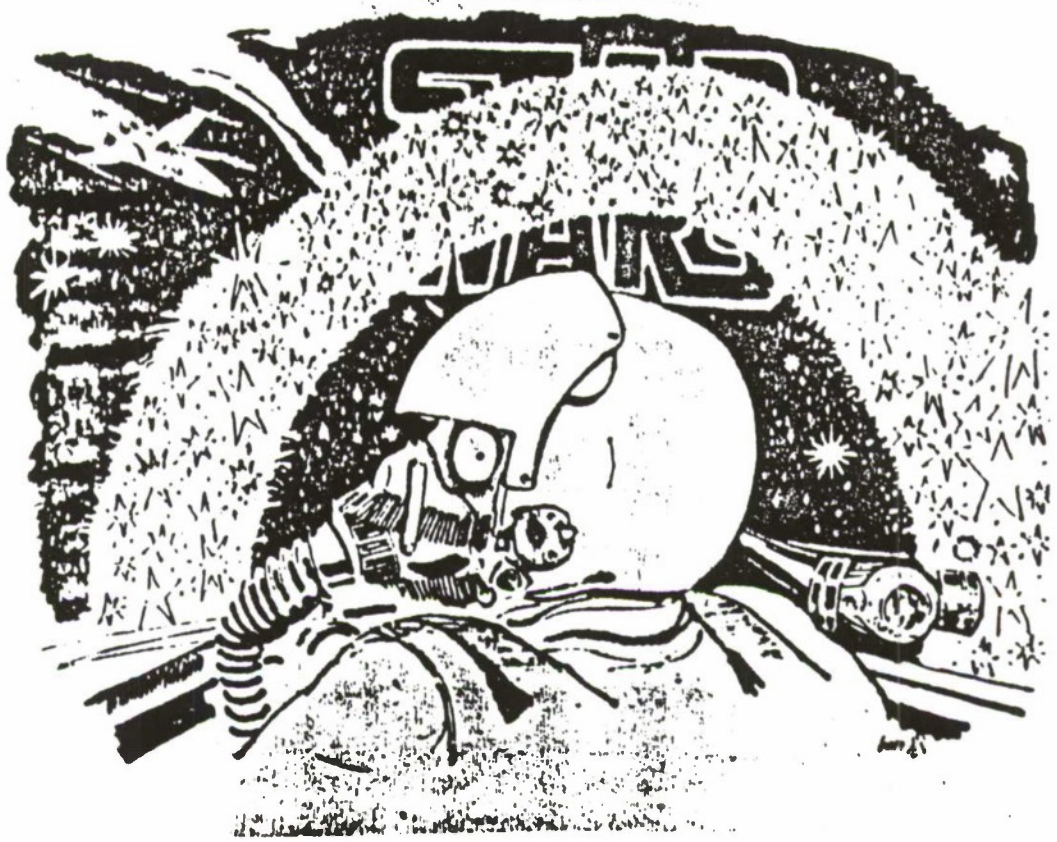
DISTRACTION POTENTIAL

- ANY MOTION ATTRACTS THE EYE

  DIFFICULT TO SUPPRESS
  - REFLEX
  - TRAINING
    - SPOT BOGIES
    - AVOID MID-AIR

- HEAD MOTIONS ABET DISORIENTATION

THE VECTION ILLUSION

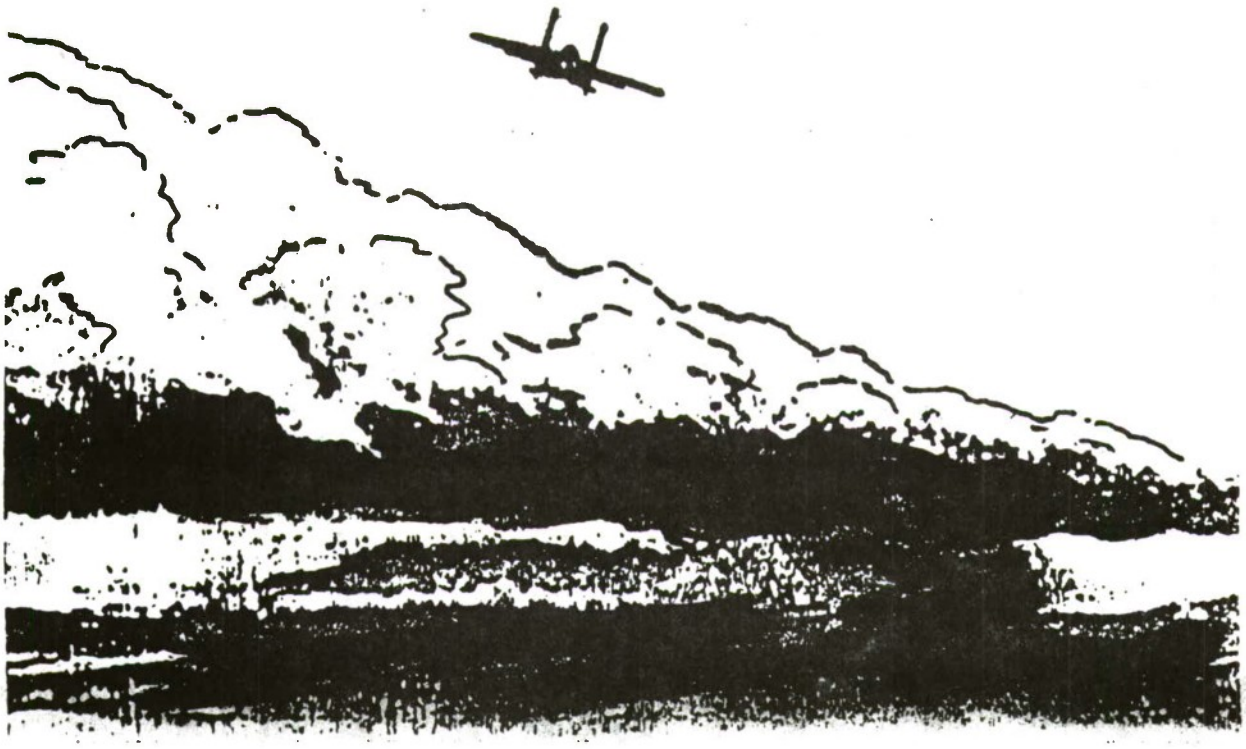


VISUAL CORTEX: RECEPTORS RESPONSIVE TO LINES

HUMAN CANNOT TOLERATE A SENSE OF DISORIENTATION

AMBIENT MODE UNCRITICAL: ANYTHING WITH QUALITY OF "HORIZONESS" = HORIZON

MASS RULE: LARGER HORIZON = MORE COMMANDING



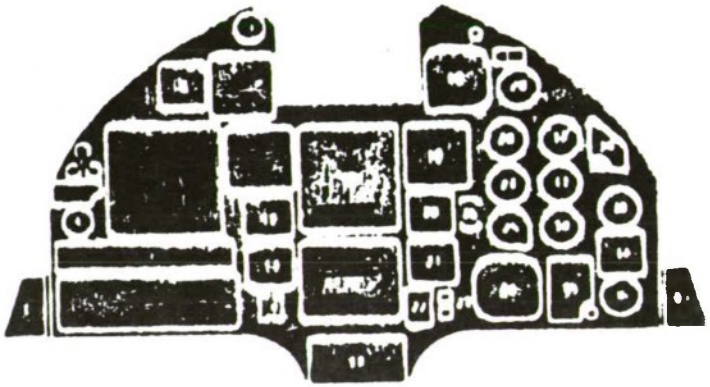


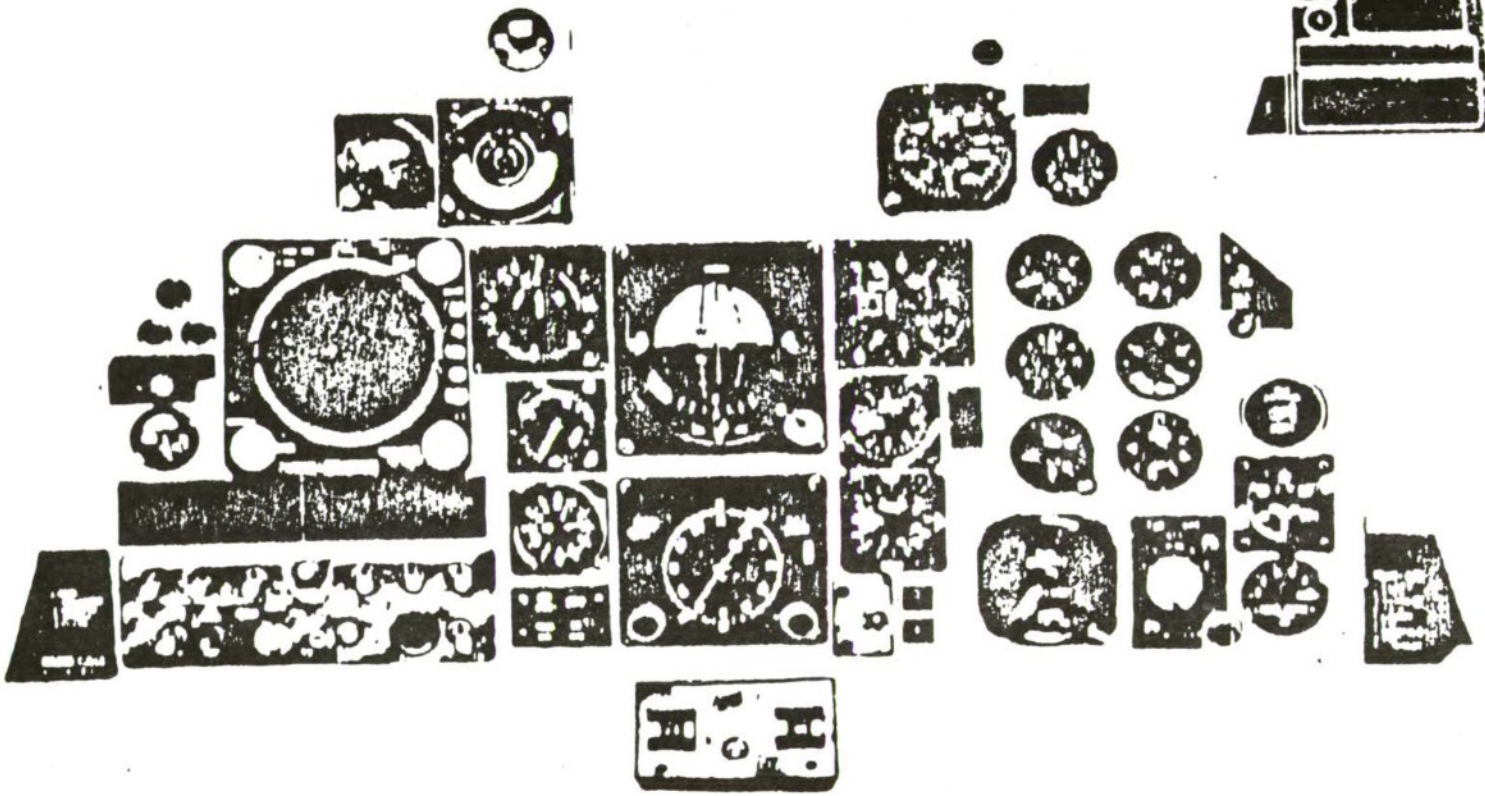
IMPACT OF SDO ON USAF

1 JAN 1971 - 1 OCT 1985

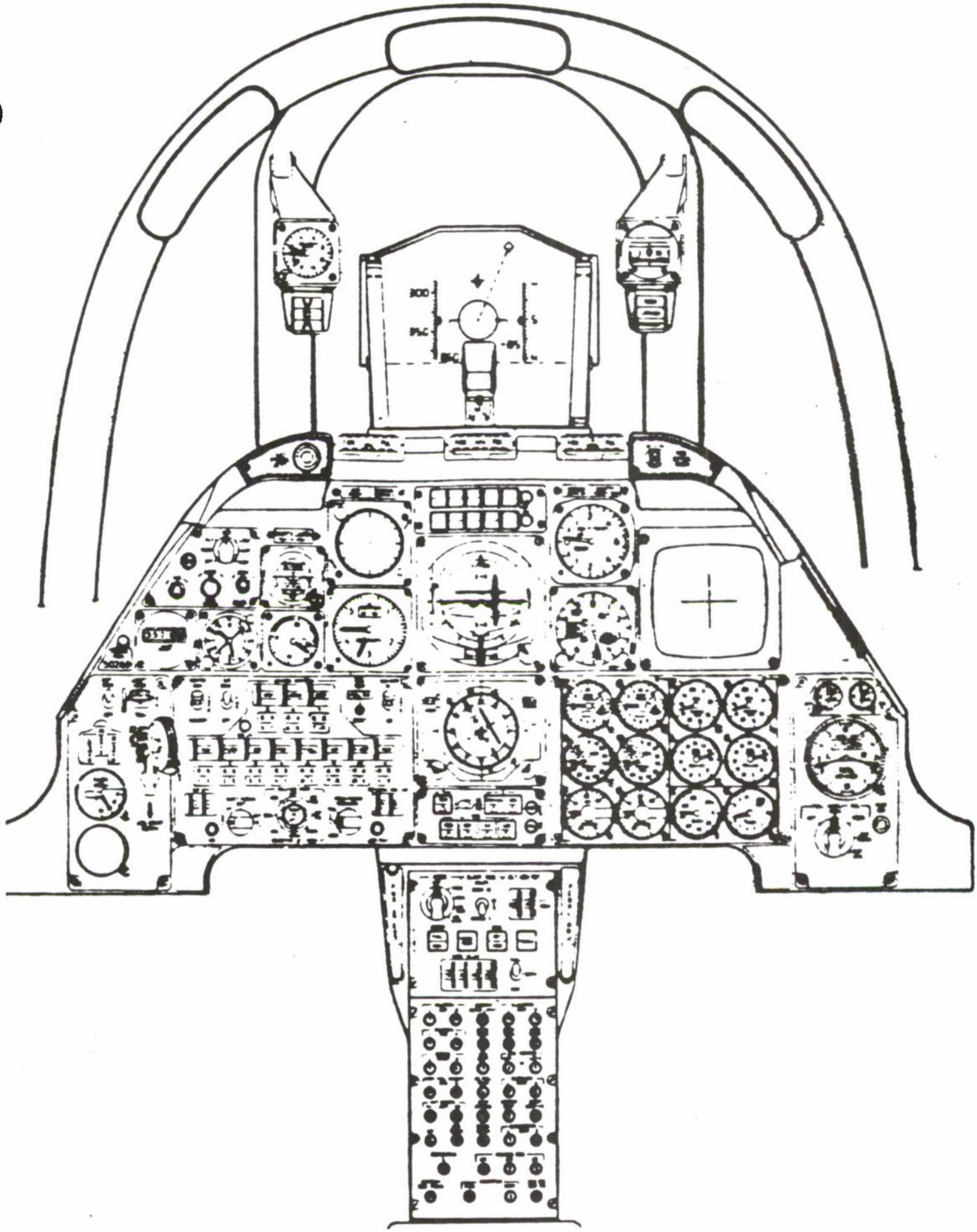
	TOTAL CLASS A	OPS FACTOR		SDO	
A-7	85	47	55%	4	9%
A-10	45	37	82%	4	11%
F-5	22	13	59%	1	8%
F-4	283	139	49%	26	19%
F-15	49	25	51%	5	20%
F-16	60	28	47%	9	32%

INSTRUMENT PANEL (TYPICAL) — [26]

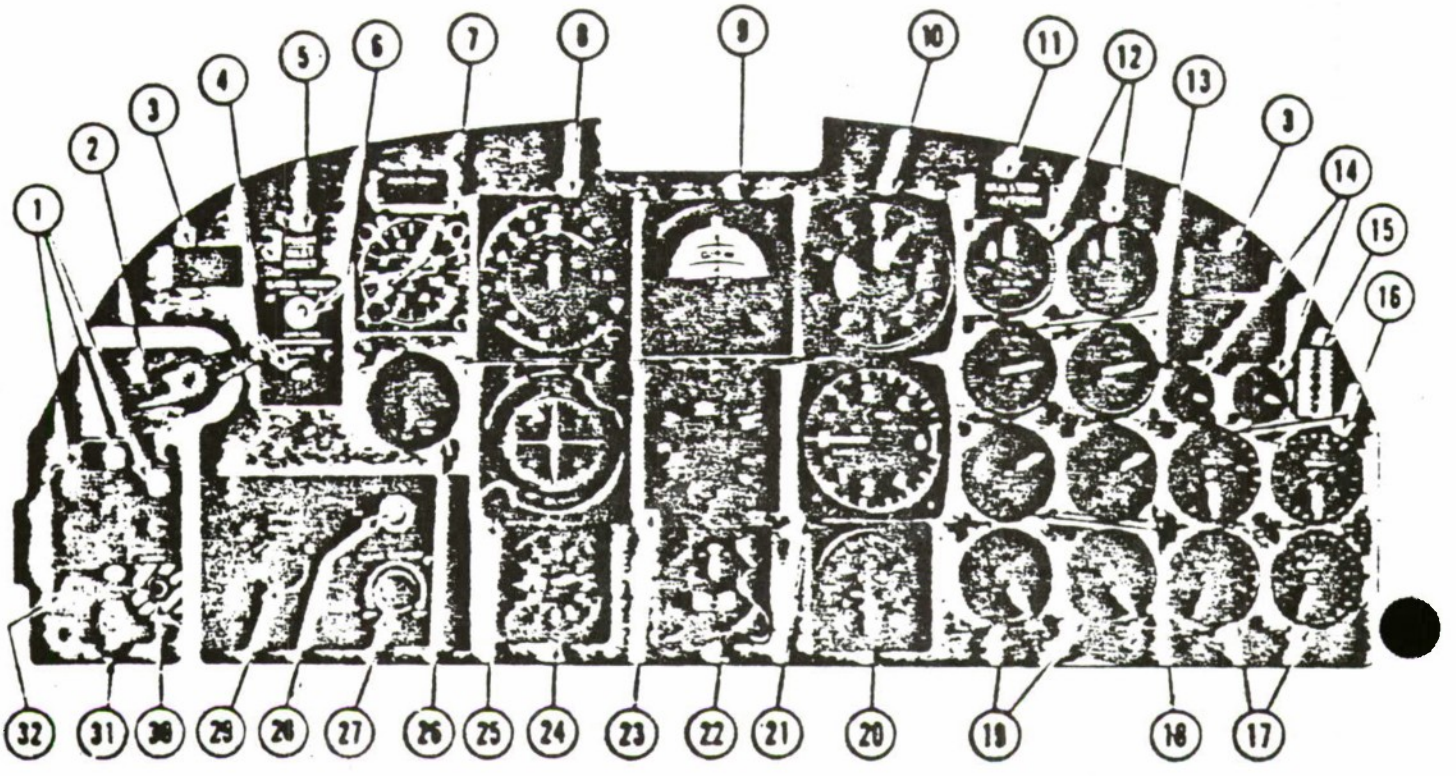


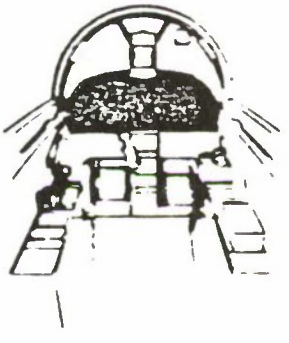


1. LAND checklist
2. ARMT select panel
3. Armament advisory light panel
4. Flap position indicator
5. LE FLAPS indicator
6. LG POS lights (3)
7. Forward looking radar
8. Standby attitude indicator
9. Speed brake indicator
10. APR 38 threat analyzer
11. Mach-airspeed indicator
12. Angle-of attack indicator
13. Clock
14. Attack master function switches (4)
15. Attitude director indicator
16. Horizontal situation indicator
17. ARMAMENT RELEASE panel
18. Radar altimeter
19. Barometric altimeter
20. Vertical velocity indicator
21. Accelerometer
22. HOG MODE switch
23. TF and LDG master function switches
24. Fuel quantity indicator
25. Turbine outlet pressure indicator
26. MASTER CAUTION light
27. Fuel flow indicator
28. Turbine outlet temperature indicator
29. Tachometer
30. FIRE warning light
31. Fire warning switch
32. Oil pressure indicator
33. Oil quantity indicator
34. Hydraulic pressure indicator
35. FUEL TANK QTY selector
36. LIQUID OXYGEN indicator
37. Cockpit pressure altimeter
38. TRUE AIRSPEED indicator
39. MKR BCN, LOW ALT lights
40. TAKE OFF checklist

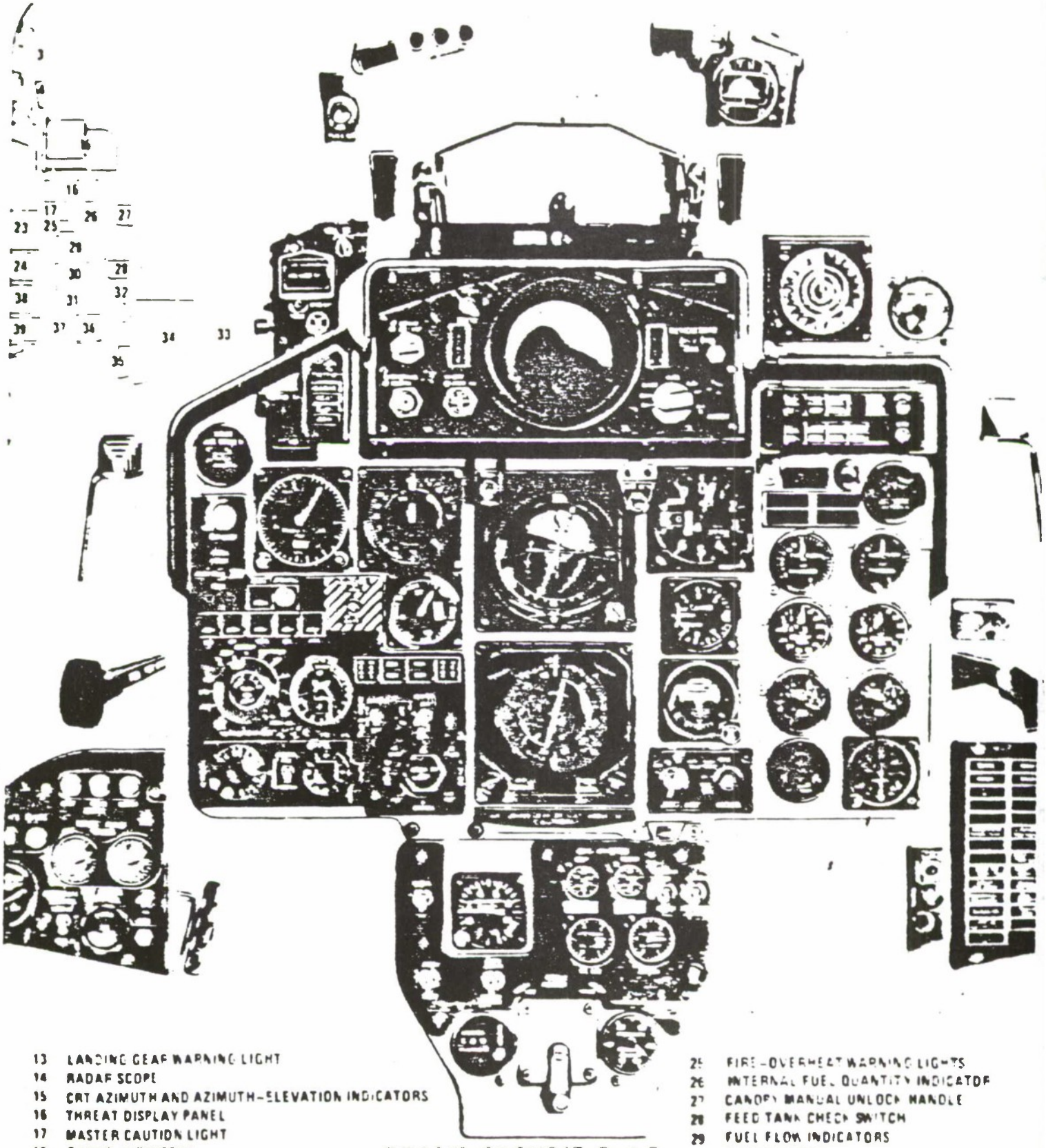


INSTRUMENT PANEL (TYPICAL)





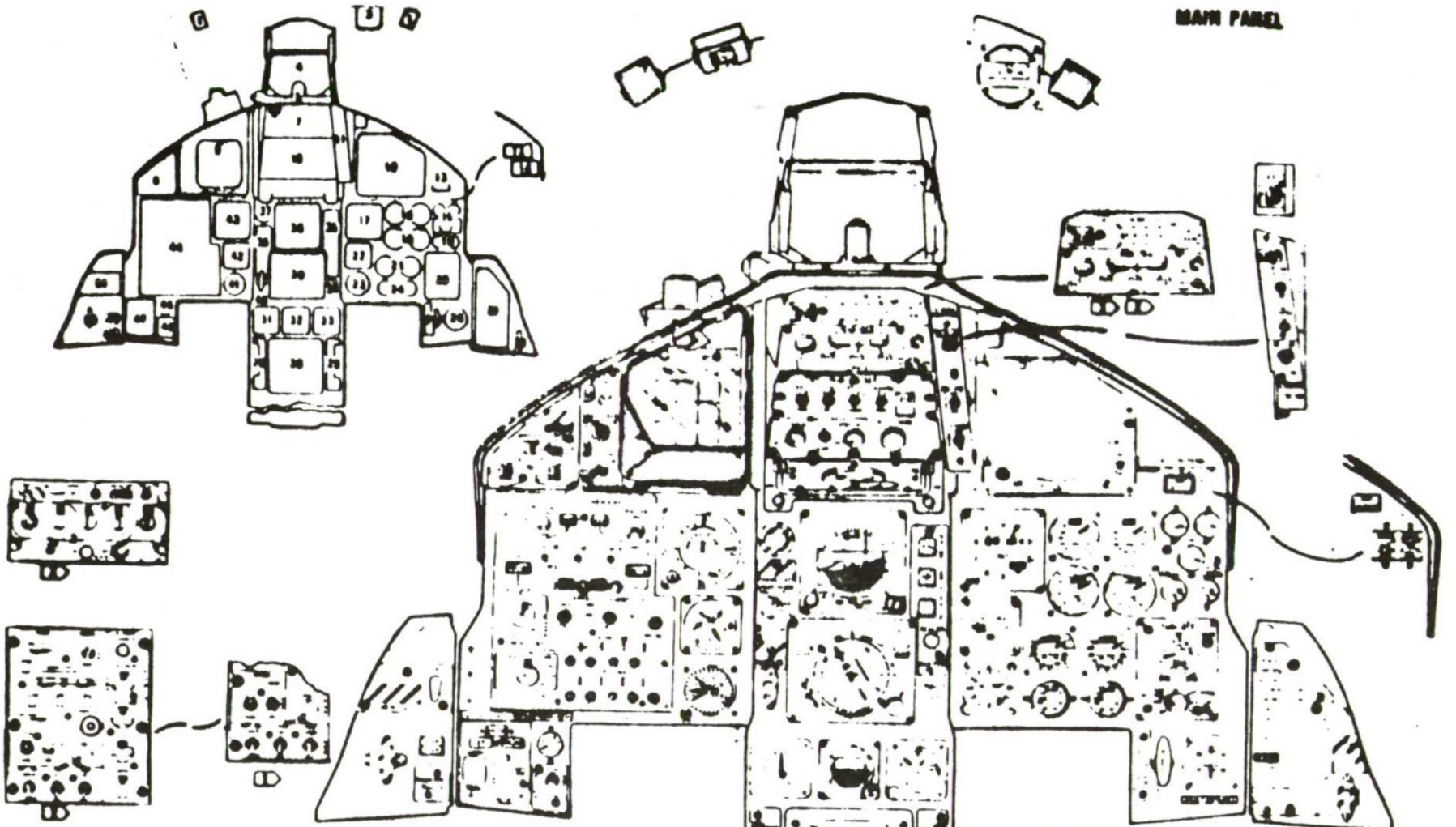
1 LANDING GEAR POSITION INDICATOR LIGHTS
2 DRAG CHUTE T-HANDLE
3 ENGINE FIRE WARNING LIGHT
4 FLAP POSITION INDICATOR
5 ATTITUDE INDICATOR FAST ERECT. SWITCH
6 GYRO POWER SWITCH
7 ACCELEROMETER
8 AIRSPEED-MACH INDICATOR
9 ATTITUDE INDICATOR
10 ALTIMETER
11 MASTER CAUTION LIGHT
12 ENGINE TACHOMETER INDICATORS
13 EXHAUST GAS TEMPERATURE INDICATORS
14 HYDRAULIC PRESSURE INDICATORS
15 CANOPY UNLOCKED WARNING LIGHT
16 OIL PRESSURE INDICATORS
17 FUEL QUANTITY INDICATORS
18 NOZZLE POSITION INDICATORS
19 FUEL FLOW INDICATORS
20 CABIN ALTIMETER
21 VERTICAL VELOCITY INDICATOR
22 TURN AND SLIP INDICATOR
23 BEARING-DISTANCE-HEADING INDICATOR
24 CLOCK
25 COURSE INDICATOR
26 HORIZONTAL TRIM INDICATOR
27 SIGHT RETICLE BRIGHTNESS CONTROL KNOB
28 SIGHT FILAMENT SELECTOR SWITCH
29 MISSILE VOLUME CONTROL KNOB
30 DOWNLOCK OVERRIDE BUTTON
31 LANDING GEAR LEVER
32 LANDING GEAR WARNING SILENCE BUTTON



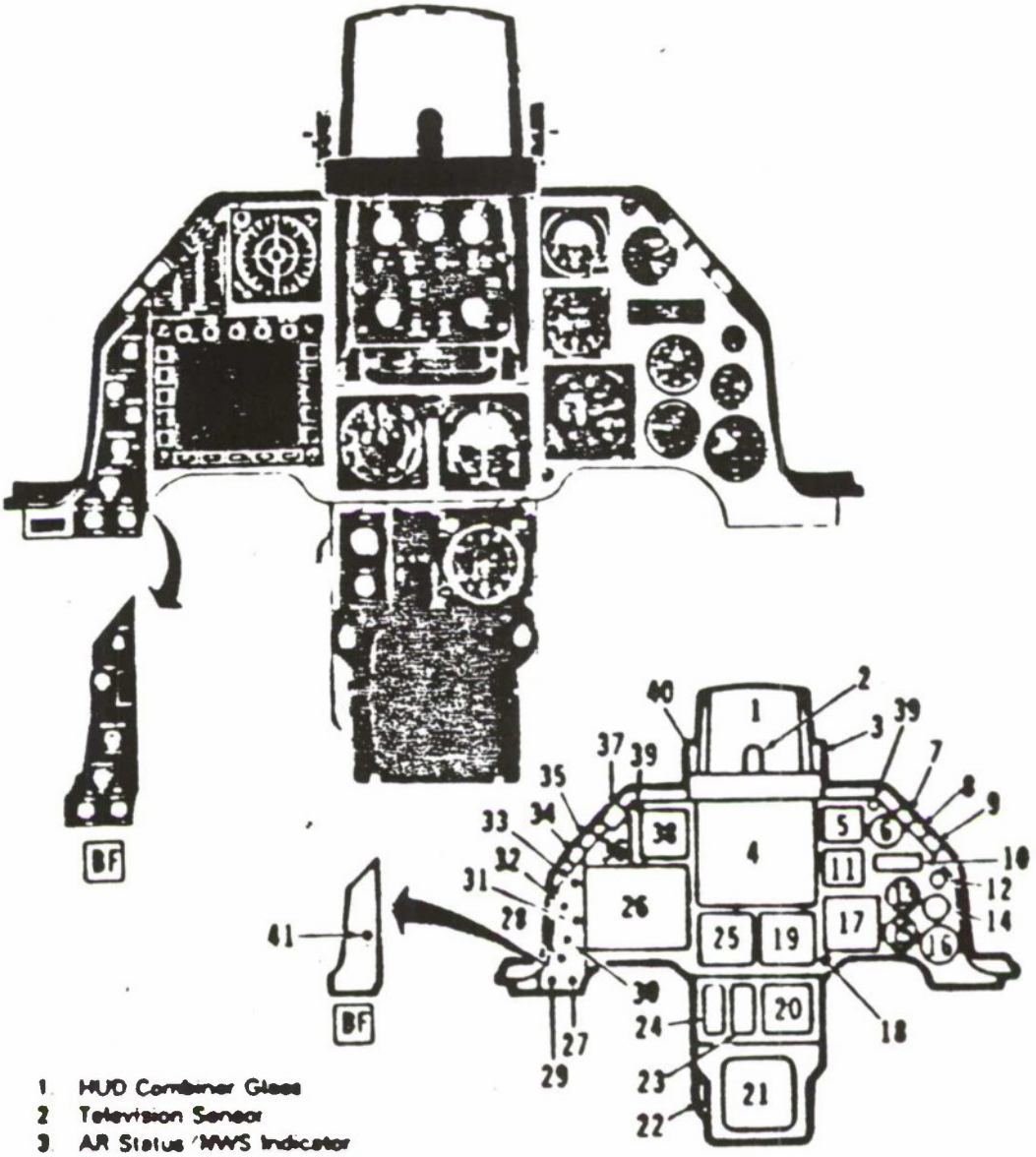
13 LANDING GEAR WARNING LIGHT
14 RADAR SCOPE
15 CRT AZIMUTH AND AZIMUTH-ELEVATION INDICATORS
16 THREAT DISPLAY PANEL
17 MASTER CAUTION LIGHT
18 RADAR ALTIMETER
19 AIRSPEED AND MACH INDICATOR
20 REFERENCE SYSTEM SELECTOR SWITCH
21 ATTITUDE DIRECTOR INDICATOR
22 MARKER BEACON LIGHT
23 ALTIMETER
24 VERTICAL VELOCITY INDICATOR

25 FIRE-OVERHEAT WARNING LIGHTS
26 INTERNAL FUEL QUANTITY INDICATOR
27 CANOPY MANUAL UNLOCK HANDLE
28 FEED TANK CHECK SWITCH
29 FUEL FLOW INDICATORS
30 TACHOMETERS
31 EXHAUST GAS TEMPERATURE INDICATORS
32 ARRESTING HOOK CONTROL HANDLE
33 INSTRUMENT LIGHTS INTENSITY CIRCUIT BREAKERS
34 RIGHT SIDE PANEL
35 KY-28 MODE LIGHT PANEL
36 EIGHT DAY CLOCK

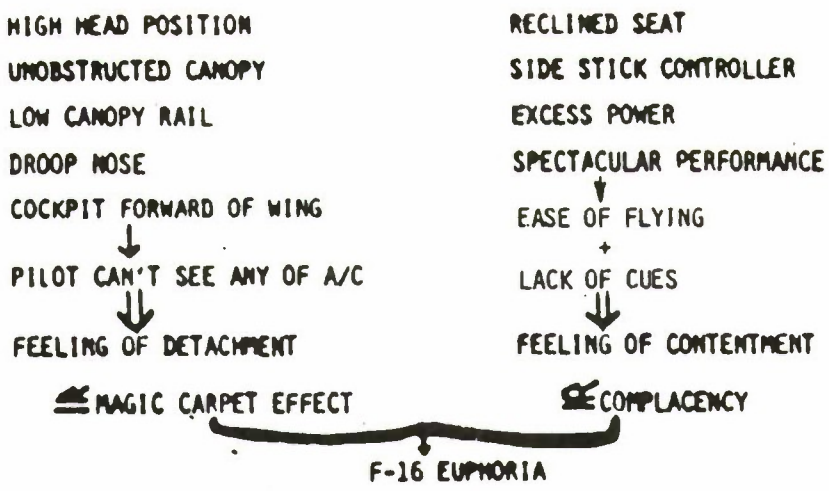
FRONT COCKPIT F-4E



F-15



1 HUD Combiner Glass
2 Television Sensor
3 AR Status/MWS Indicator
4 HUD Control Panel
5 Standby Attitude Indicator
6 Fuel Flow Indicator
7 DUAL FC FAIL Warning Light (Red)
8 HYD/OIL PRESS Warning Light (Red)
9 CANOPY Warning Light (Red)
10 Radio Channel Frequency Indicator
11 Vertical Velocity Indicator
12 Oil Pressure Indicator
13 RPM Indicator
14 Nozzle Position Indicator
15 FTIT Indicator
16 Fuel Quantity Indicator
17 Altimeter
18 MRK BCN Light
19 Attitude Director Indicator
20 Horizontal Situation Indicator
21 Radar/EO Display
22 Rudder PEDAL ADJ Knob
23 AOA Indicator
24 Instrument Mode Select Panel
25 Airspeed Mach Indicator
26 Stores Control Panel
27 Autopilot ROLL Switch
28 AUTOPILOT Switch
29 Autopilot PITCH Switch
30 MASTER ARM Switch
31 ALT REL Button
32 SMS PWR Switch
33 IFF IDENT Button
34 ENG FIRE Warning Light (Red)
35 T O /LAND CONFIG Warning Light (Red)
36 THREAT WARNING Controls and Indicators
37 MASTER CAUTION Light (Amber)
38 THREAT WARNING Azimuth Indicator
39 Spotlights
40 AOA Indexer
41 [illegible]OVRD Light



IMPLICS: TIME SENSE, CROSS-CHECK, S.A.

LOSS OF S.A. POTENTIAL: F-16

- HEAD HIGH IN FISHBOWL
  - LACK NATURAL ATTITUDE REFERENCES
  - AMBIENT MODE BOMBARDMENT
- CANOPY GLARE & REFLECTIONS
  - INSTRUMENTS = WHITE BAND
  - RADAR = GREEN BAND
- INSTRUMENT LIGHTING
  - DME ON HSI
  - VVI

LOSS OF S.A. POTENTIAL: F-16

- FLIGHT CHARACTERISTICS: DECEPTIVE
  - LACK OF AUDITORY/TACTILE CUES TO AIRSPEED
  - DOESN'T "TALK" TO THE PILOT
- AERIAL REFUELING LIGHT = FALSE HORIZON
- FORMATION LIGHTS

LOSS OF SA POTENTIAL: F-16

- HAVE TO FLY WITH EYEBALLS =

  HAVE TO FLY IT CONSTANTLY

- NO CLUE THAT ANYTHING HAS CHANGED

- HARD TO TRANSITION OUTSIDE TO IN

WHAT DOES THE PILOT NEED TO RECOGNIZE, COMBAT AND COPE WITH SDO, FALSE HORIZONS, NO HORIZON?

A BIG ATTITUDE INDICATOR

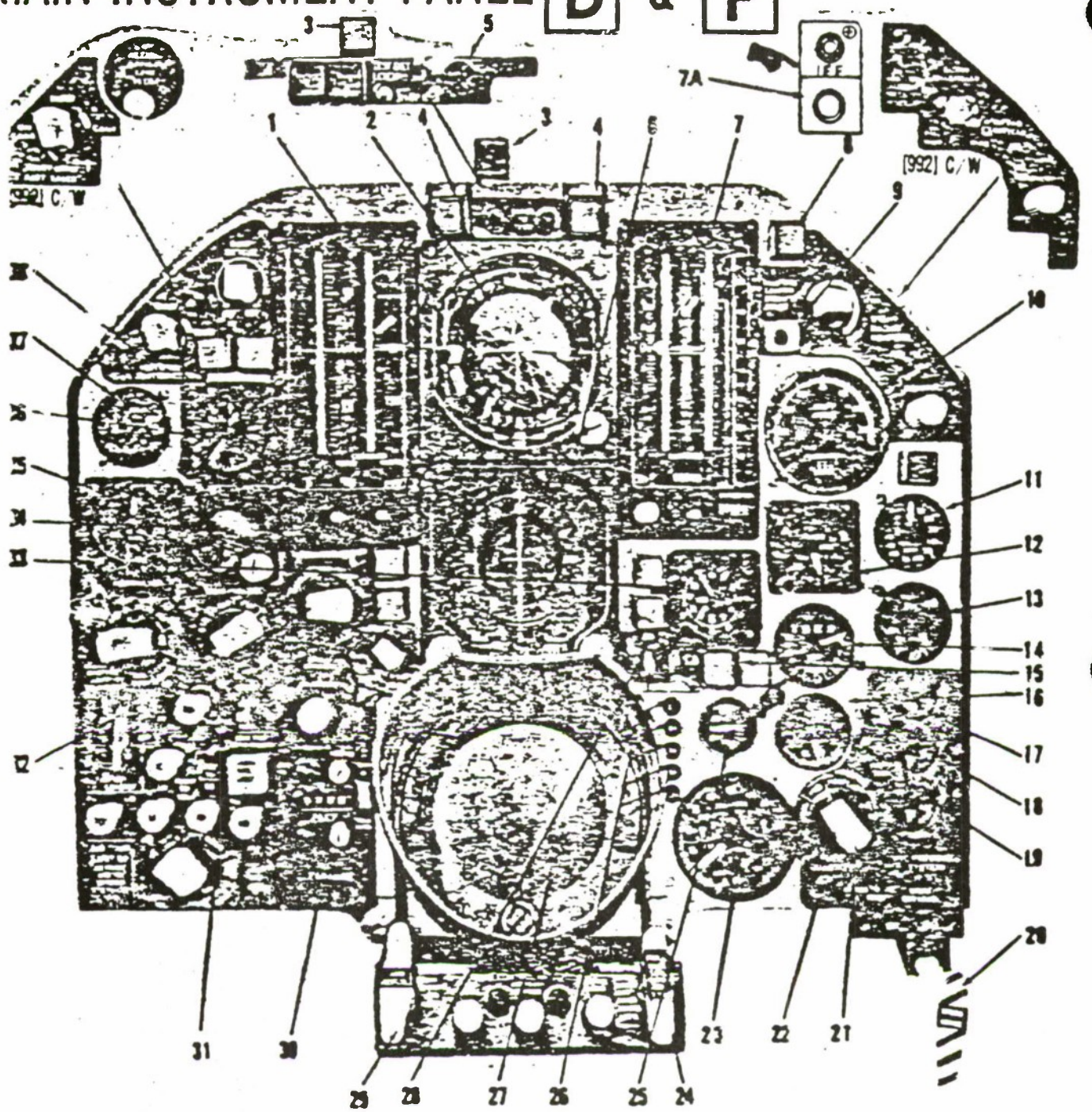
- THE BIGGER THE BETTER!
- IDEALLY BIG ENOUGH TO SEE OUT CORNER OF EYE - AS IN FLYING FM.

IMPORTANCE OF THE ATTITUDE INDICATOR

- THE HUB OF THE CROSS-CHECK IN IMC 70-90% EYE-TIME
- PROMINENT, LARGE, CENTRALLY LOCATED
- IDEALLY BIG ENOUGH TO SEE OUT CORNER OF EYE
  - FACILITATE TRANSITION OUTSIDE TO INSIDE
  - SNEAK-A-PEEK FLYING FORMATION
  - TO MAINTAIN ATTITUDE AWARENESS
  - TO SPEED RECOGNITION OF UNEXPECTED ATTITUDE AND FACILITATE COPING

TYPICAL

MAIN INSTRUMENT PANEL D & F



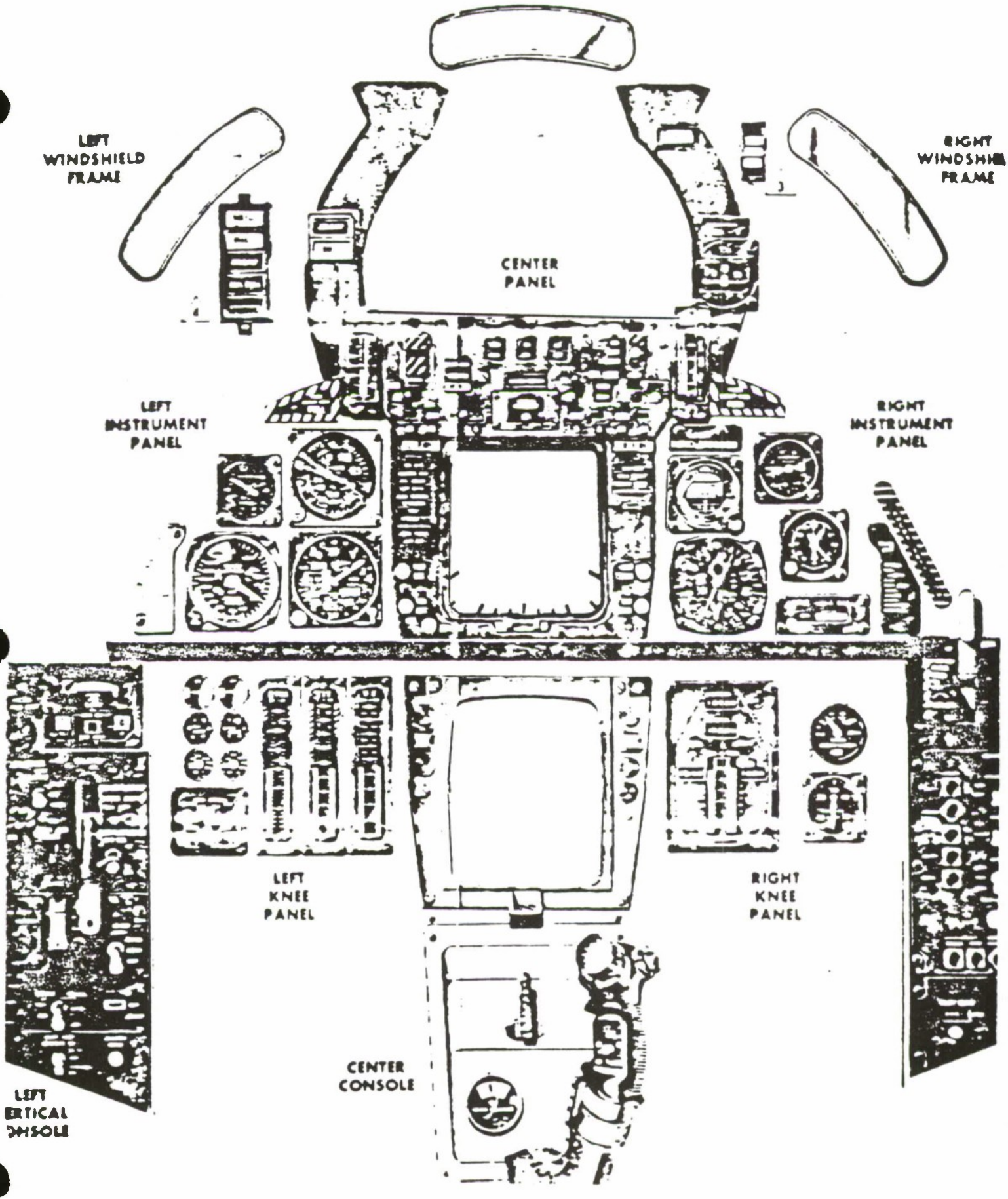
- AMI (Airspeed Mach Indicator)
- ADI (Attitude Director Indicator)
- Stabilizer Lock Light [1045] C/W
- Engine Overheat and Fire Warning Lights
- Fire Extinguisher Button 1060 C/W
- HSI (Horizontal Situation Indicator)
- AVVI (Altitude-Vertical Velocity Indicator)
- IFF Caution Light
- Bail-Out Light (F only)

10. Ground Speed and Drift Angle Indicator
11. Tachometer
12. Pressure Ratio Gage

All caution, warning and indicator lights are presented in detail in Figure 1-60.

All armament controls are presented in T.O. 1F-105B-34-1-1.

See T.O. 1F-105G-1 for G cockpit configuration.


LEFT WINDSHIELD FRAME
RIGHT WINDSHIELD FRAME
CENTER PANEL
LEFT INSTRUMENT PANEL
RIGHT INSTRUMENT PANEL
LEFT KNEE PANEL
RIGHT KNEE PANEL
CENTER CONSOLE

STANDBY ATTITUDE INDICATOR (SAI)

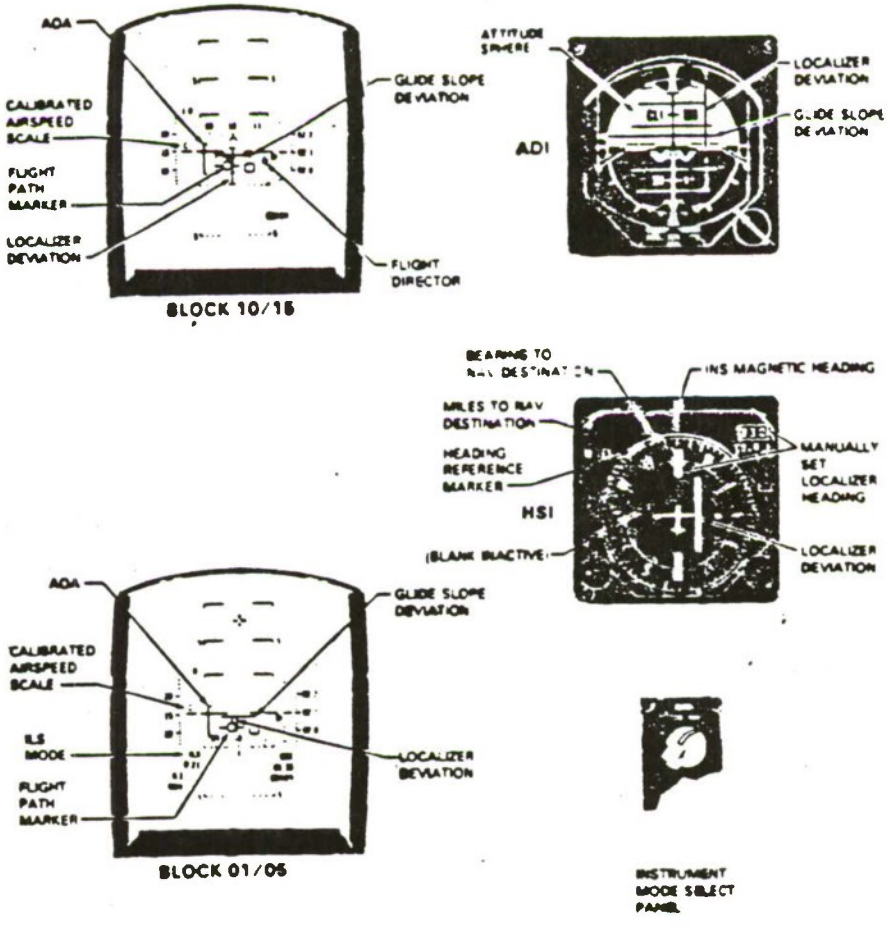
- POSITION RELATIVE TO ADI
  - MISMATCH RECOGNITION
  - COMPOSITE CROSS CHECK
- RELIABILITY ISSUES

PROBLEM WITH HUD'S

- **DIGITAL**
- **CLUTTERED**
- **CONFUSING**

Instrument Modes

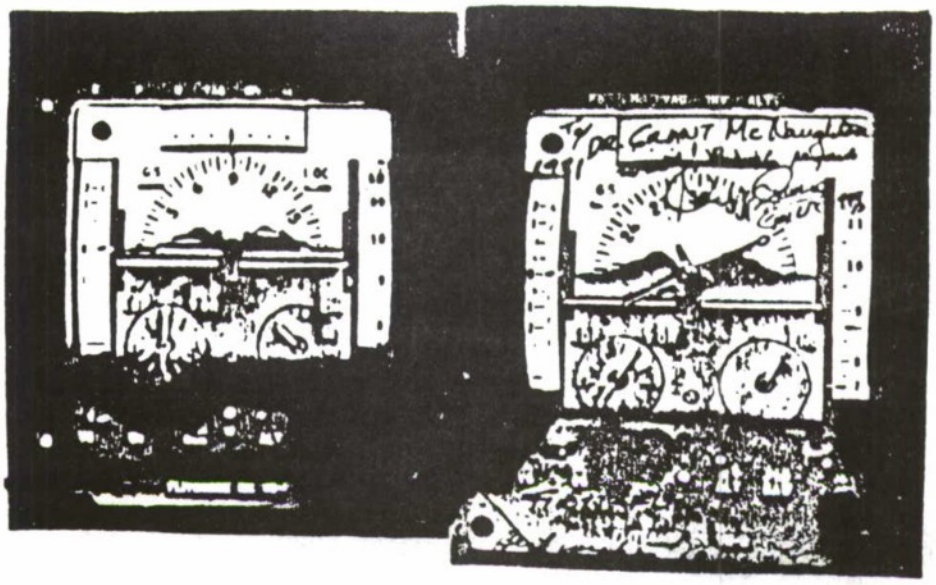
ILS/NAV US DE NO



NOTE: Glide slope and localizer bars indicate deviation only, not steering

ALWEATHER FLITEGAGE

Model VII



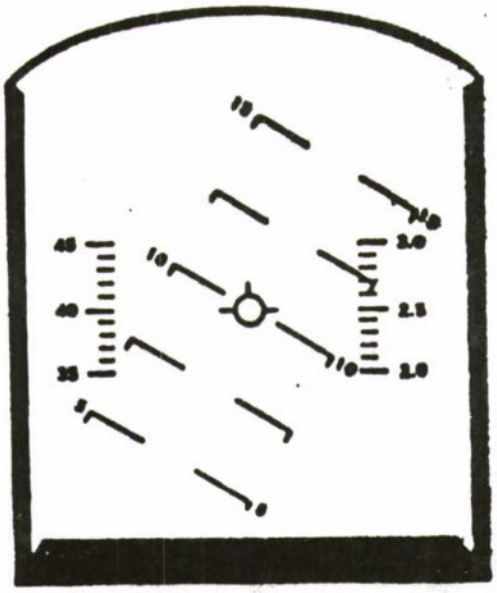
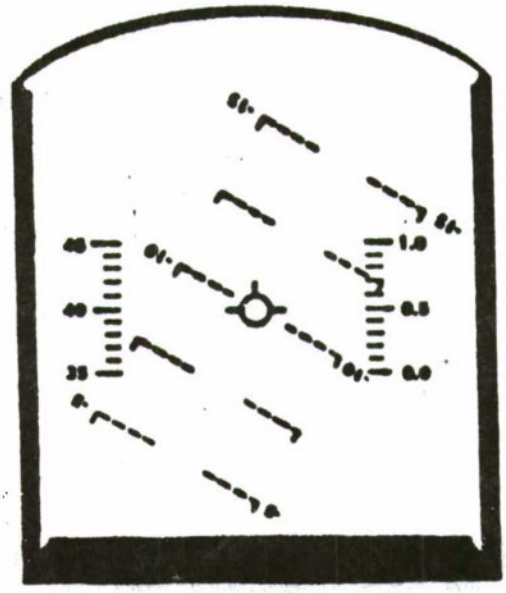
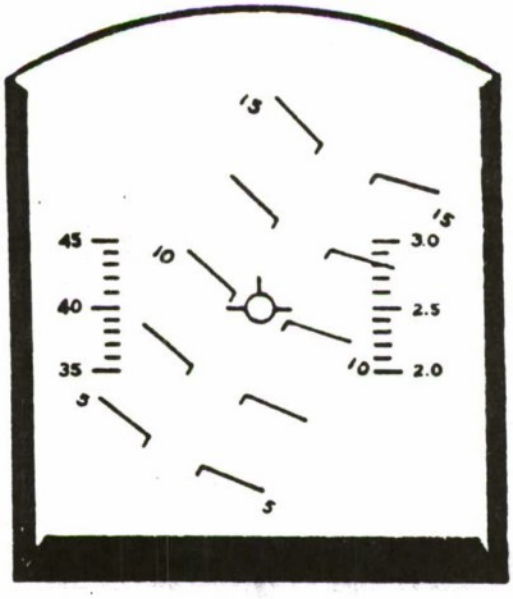
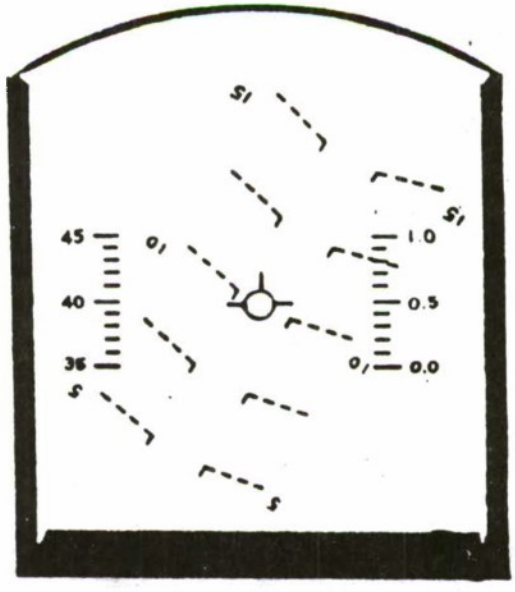


At the moment the aircraft entered IMC, the ADI would have looked something like this.



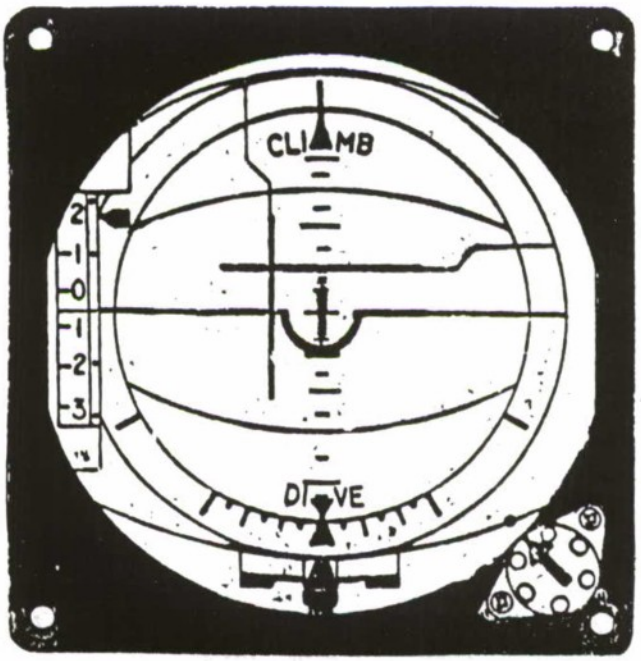
At the moment of impact, the ADI would have looked like this. The barrel of the ADI is less than 2" in diameter, as in this figure. It is located between the knees, 24" to 34" from the Design Eye Point. Could it be possible to confuse these indications, such as at night, with canopy reflections?

Note: Horizon line subtends an angle of only 3.4° to 4.8° at the eye - not particularly commanding.

SPATIAL MIS ORIENTATION

- INSIDIOUS - PILOT UNAWARE OF ODD ATTITUDE
- COMFORTABLE - LACK OF VERTIGO DELAYS X-CHECK
- EXPECTANCY - UNALERTED, WHEN HE FINALLY X-CHECKS, HE MAY SEE WHAT HE EXPECTS TO SEE
- INSTRUMENT MISREAD/MISINTERPRETED, HE MAY DO JUST THAT
  E.G.: FTR HUD ATTITUDE DISPLAY



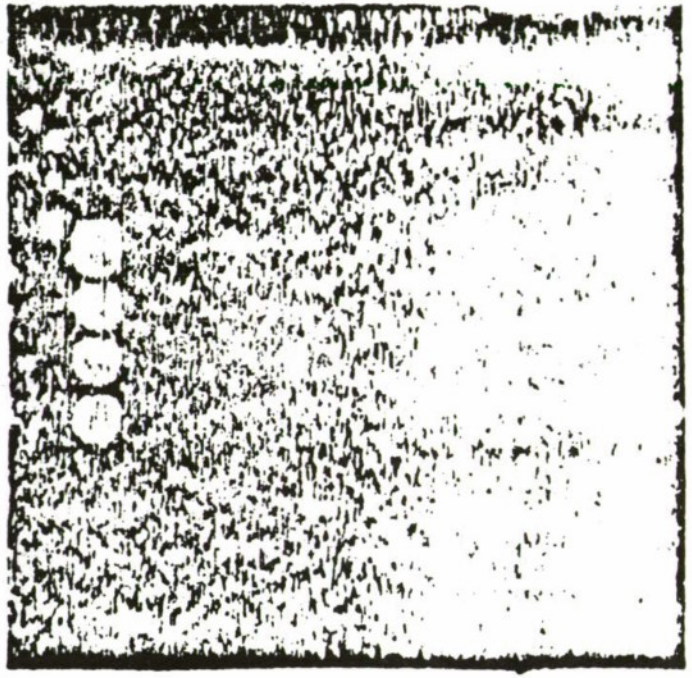




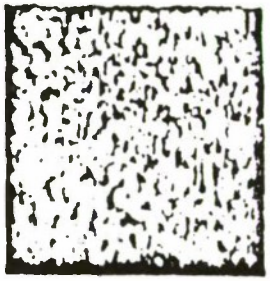
16°
Early
A-H
1930



27°
J-8
1940



110° X 110°
STD ADI
1960



40° X 40°
B-1
1970



20° X 30°
F-16
1980



15° X 15°
C-17
1980



10° X 10°
HH-60
1990?

Display Field of Regard Comparison

	ADI	HUD
FIELD OF VIEW	90°	16°
MOTION	STABLE	DYNAMIC
ROLL	SENSING BACKWARDS	SENSING BACKWARDS
PITCH	AIRCRAFT ATTITUDE	VELOCITY VECTOR
UNUSUAL ATTITUDE RECOGNITION & COPING	EASIER	VERY DIFFICULT - SUBJECT TO MISINTERPRETATION
DECEPTIVE ASPECTS	TOP ONE-HALF MAY APPEAR UNIFORM UNDER CERTAIN G&R	TENDENCY TO STARE & MESMERIZING WITHOUT PROCESSING INFORMATION

HUD ATTITUDE INDICATION IMPROVEMENTS

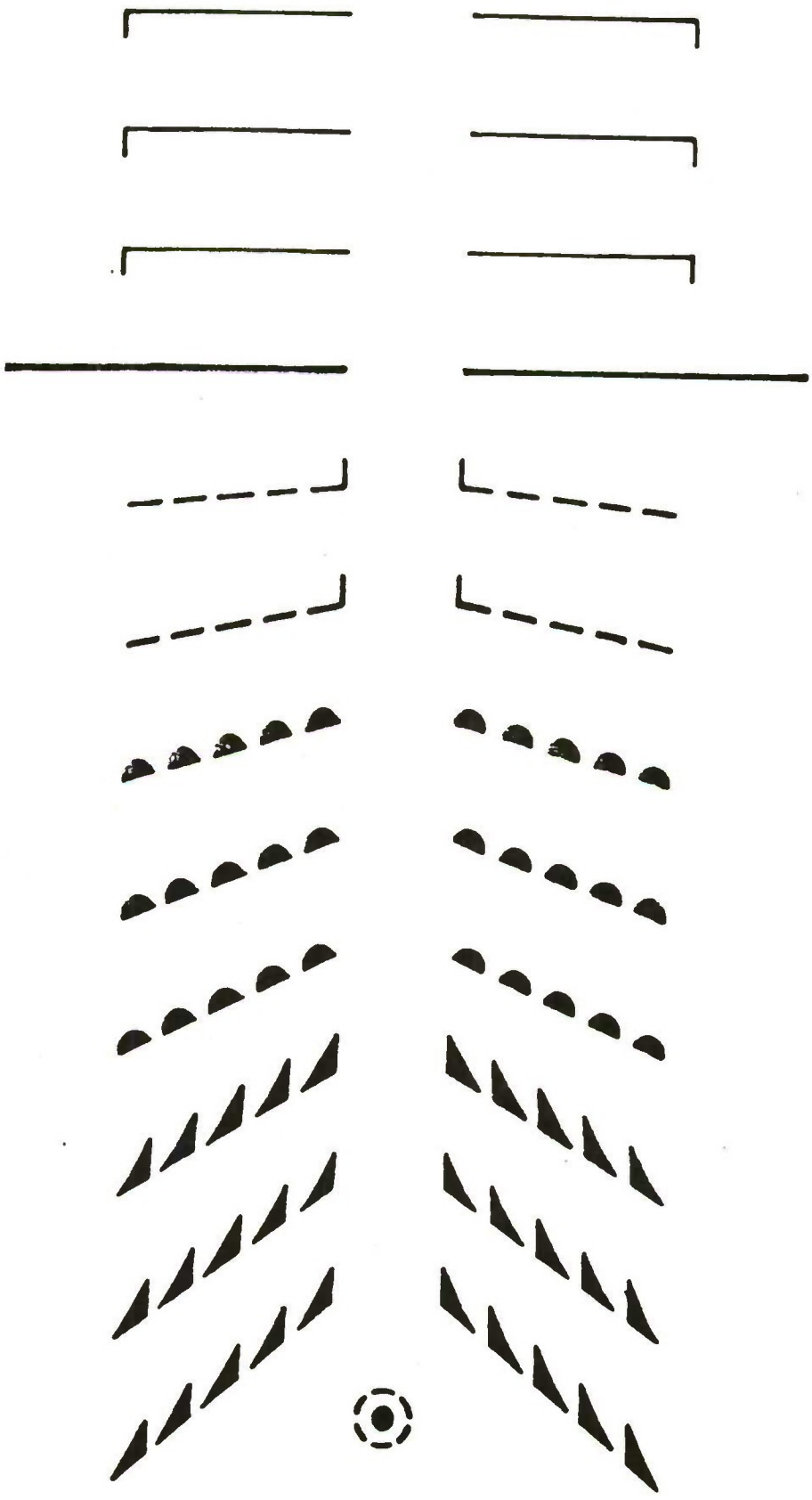
- FPM - SKY POINTER
- PITCH SCALES - RADICALLY CHANGE PATTERN BETWEEN (+) AND (-), AND WITHIN (-)



VERTEX POINTING STAR ON FLIGHT PATH MARKER

TO GET UPRIGHT,
POINT FPM TAIL
AT THE STAR

HUD PITCH SCALE SHOWING
RADICAL CHANGES FROM POSITIVE
TO NEGATIVE & WITHIN NEGATIVE



HABIT PATTERN

- LEARNING IS HARD, BUT
  FORGETTING IS HARDER YET

- APPLIES TO LOCATION OF
  - SWITCHES
  - EJT HANDLES
  - INSTRUMENTS

PILOT-VEHICLE INTERFACE

- WHAT'S HE NEED?
  - ATTITUDE CUES
  - AIRSPEED "
  - ALTITUDE "

  } W/OUT HAVING TO DWELL ON INSTRUMENTS

- HAVE WE CONSIDERED ADEQUATELY HOW THE BRAIN & PERCEPTUAL SYSTEM WORK IN FORMATTING THE PVI?
  - PROPER MIX OF PATTERN, PICTORIAL, COLOR, ORIENTATION, ANALOG, DIGITAL FOR FOCAL & AMBIENT VISUAL MODES

- DOES THE AIRCRAFT TALK TO THE PILOT?
  - AUDITORY, KINESTHETIC CUES

SOME CHARACTERISTICS OF MAN AS A SYSTEM COMPONENT

- PERCEPTUAL ABILITIES
  - SENSITIVE SOUND & LIGHT DETECTORS
  - GOOD PATTERN & OBJECT RECOGNITION
  - SUBJECT TO HEIGHT/DISTANCE MISJUDGMENTS, TUNNEL VISION, DISTRACTION, ILLUSIONS
  - POOR TIME SENSE

- LIMITED PROCESSING RATE
  - " INPUT RATE
  - " THINKING RATE
  - " MOTOR-OUTPUT RATE

  LARGELY SINGLE-CHANNEL OPERATION

- ERROR PRONE
  - LIMITED PRECISION
  - SEQUENCE STEP OMISSIONS
  - HABIT PATTERN REVERSIONS
  - SUBJECT TO FATIGUE AND IRREGULAR PERFORMANCE

- FLEXIBLE CONTROL
  - SELF-REPROGRAMMABLE
  - ADAPTABLE
  - POOR MONITOR
  - NEEDS MOTIVATION

- REQUIRES SPECIALIZED LIFE SUPPORT EQUIPMENT

CHARACTERISTICS OF MAN RE DISPLAYS

- MAN = PATTERN RECOGNIZER

  MORE INFO ORGANIZED VISUALLY = FASTER ACQ/UNDERSTANDING

  PICTURE'S WORTH A 1000 WORDS

- USUALLY WANTS ONLY TO KNOW WHETHER PARAMETER HAS CHANGED

  DIGITALS/CC-NUMERICS/SYMBOLS → FOCAL MODE: READ, DECODE, INTEGRATE

  - NO INHERENT TREND/LIMITATIONS INFO

  ANALOG → AMBIENT & FOCAL MODES: FASTER, BOTH TREND & LIMITATIONS INFO

  - CAN BE MISREAD

- ATTENTION TRAPS: ANY DISPLAY TRAPPING PILOT'S ATTENTION CAN KILL HIM

ALTITUDE AWARENESS

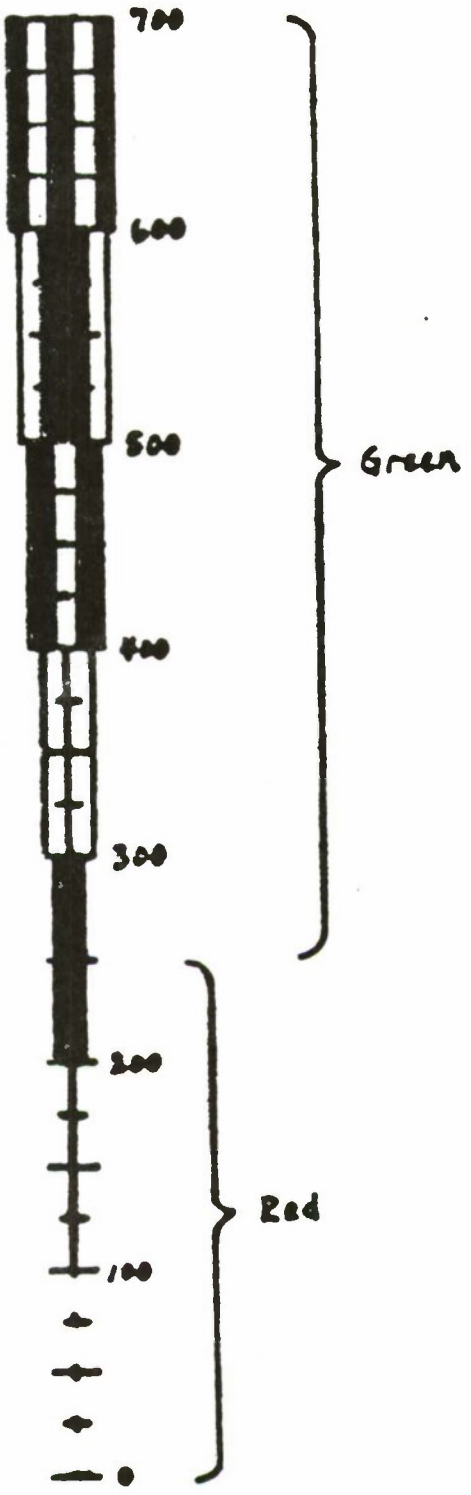
- AUDITORY
  - DATUM-PLANE TONE - SELECTABLE
  - PREDICTIVE GPWS
  - CALLOUT OF SELECTED PARAMETERS ON REQUEST
- VISUAL
  - ALTIMETER - PATTERNED FOR INSTANT UNLQUIVOCAL APPRECIATION
  - RADAR ALTIMETER - PATTERNED LIKEWISE

CRITICAL CONTROL PARAMETERS

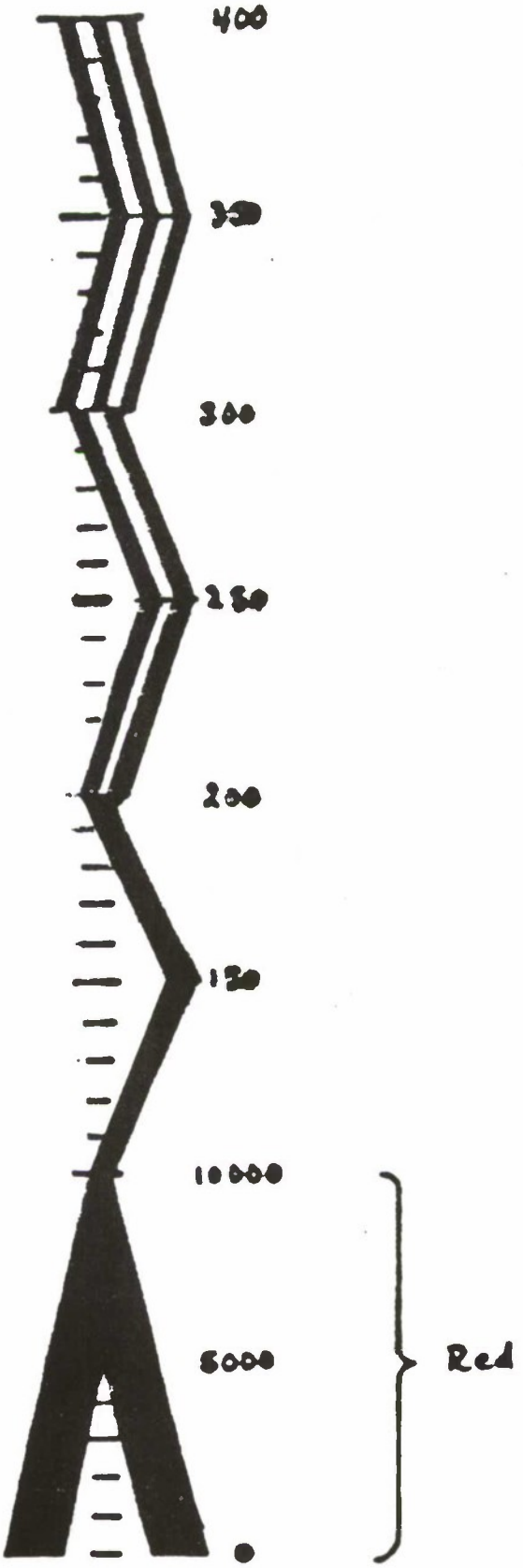
- ATTITUDE, AIRSPEED, ALTITUDE ± HEADING, VERTICAL VELOCITY, ANGLE OF ATTACK
- PRESENT DISPLAYS -

  REQUIRE FOCAL MODE PROCESSING TO READ & DECODE
  - " MENTAL EFFORT TO INTEGRATE
  - " TIME INVESTMENT TO OBTAIN TREND INFO
  - " MORE MENTAL EFFORT FOR LIMITATIONS/MEANING

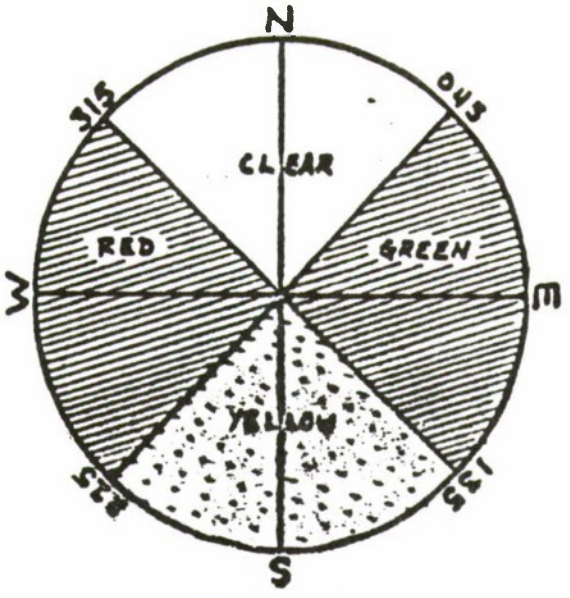
PROPOSED AIRSPEED DISPLAY



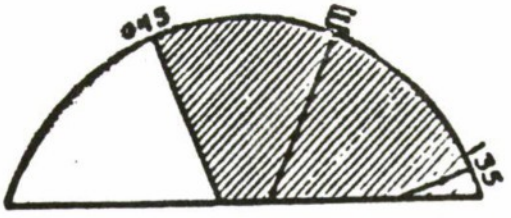
PROPOSED ALTIMETER DISPLAY



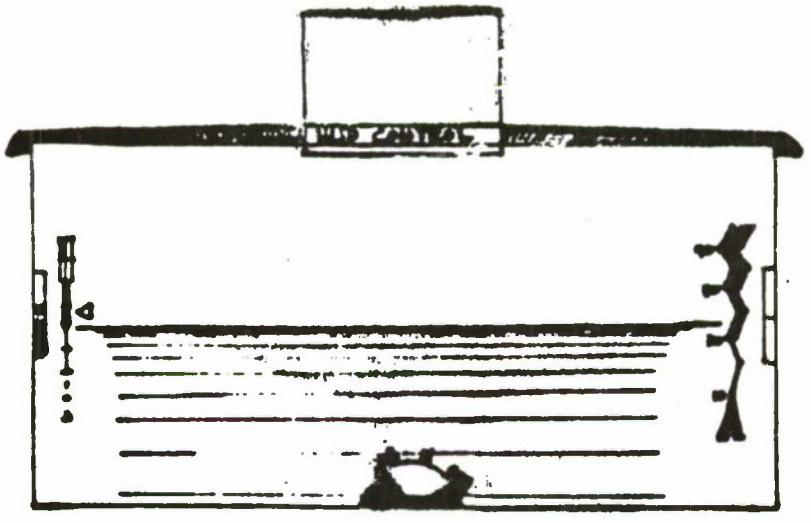
PROPOSED HEADING DISPLAY

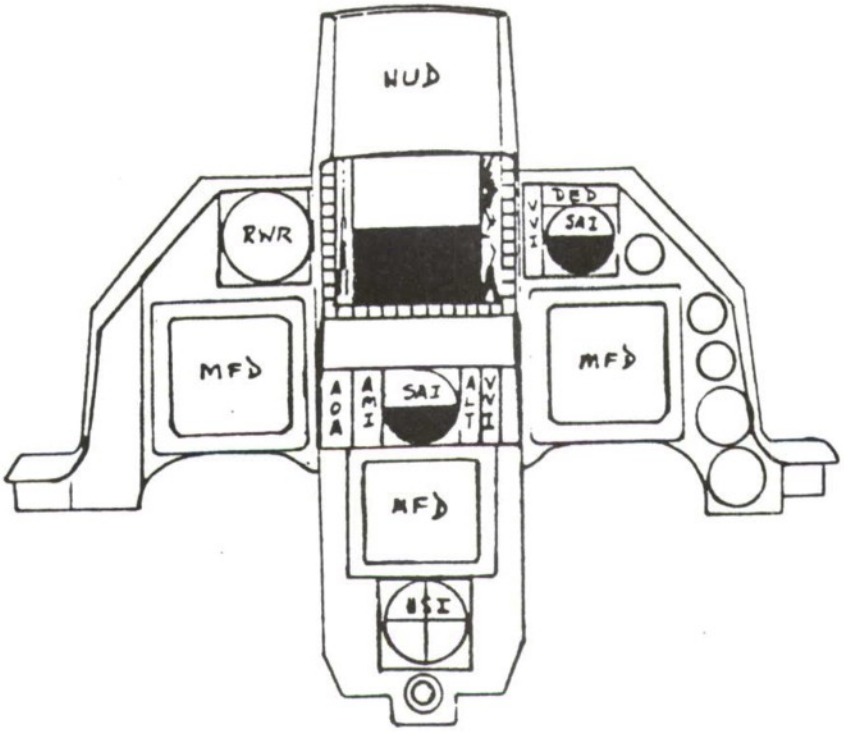


FULL COMPASS

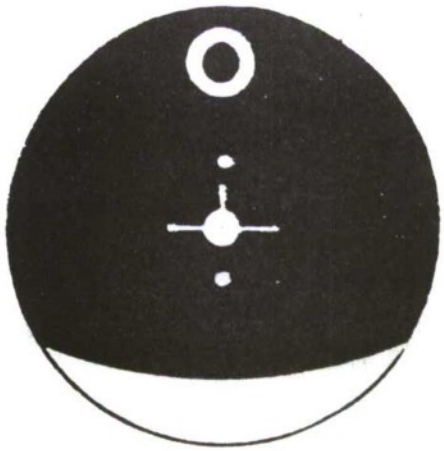


VISIBLE PORTION









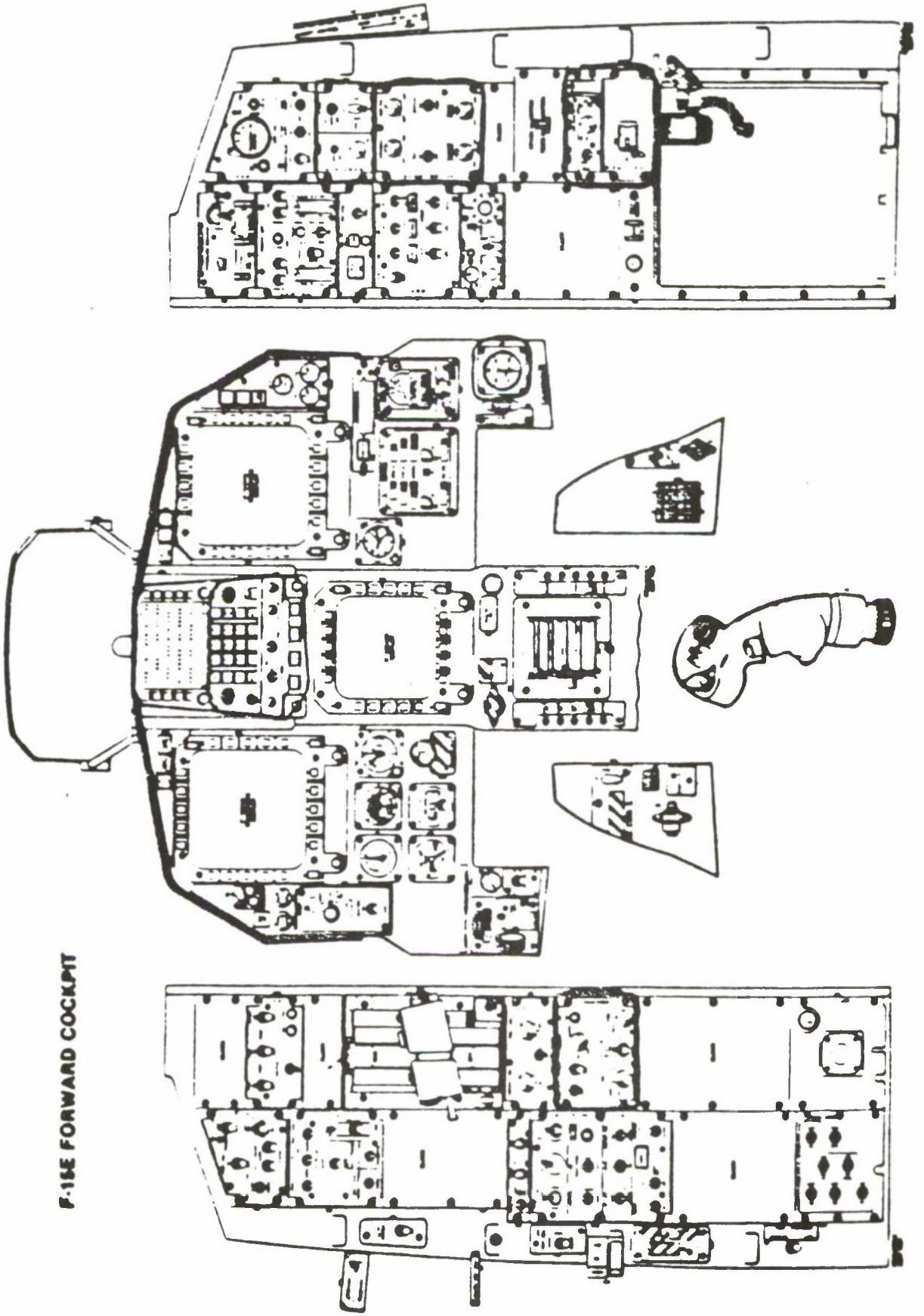
ATTITUDE INDICATION FORMATS

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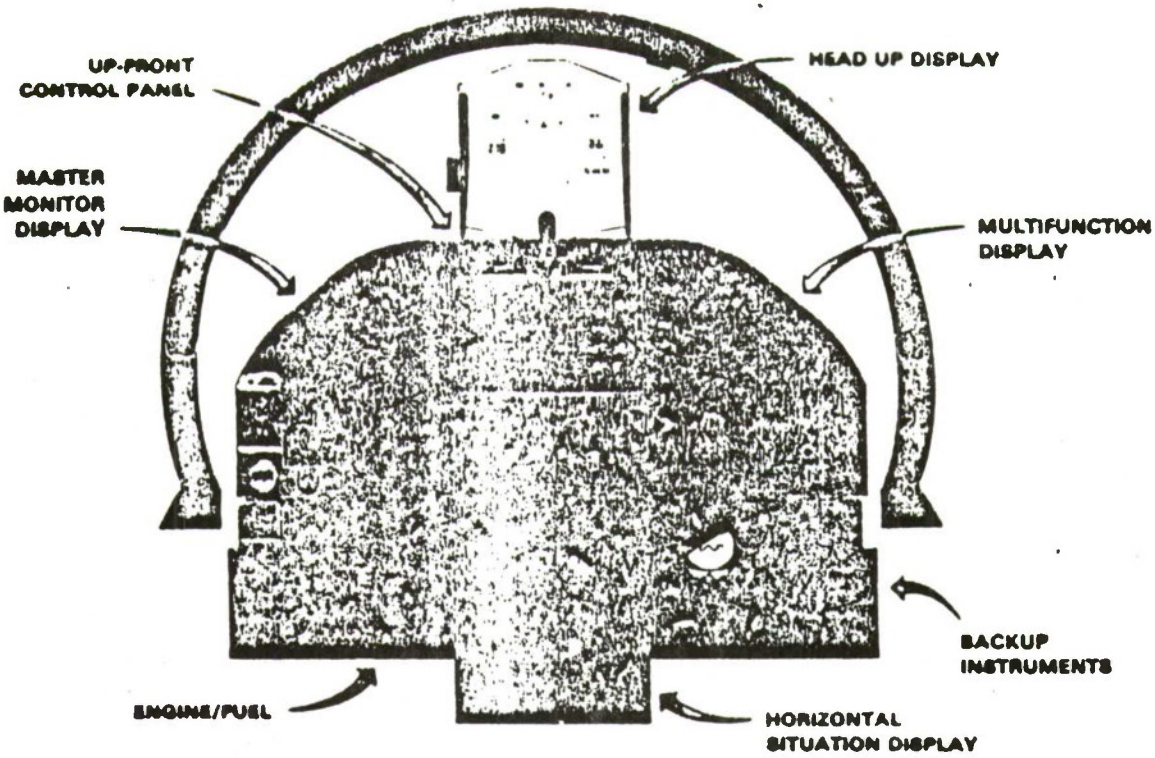
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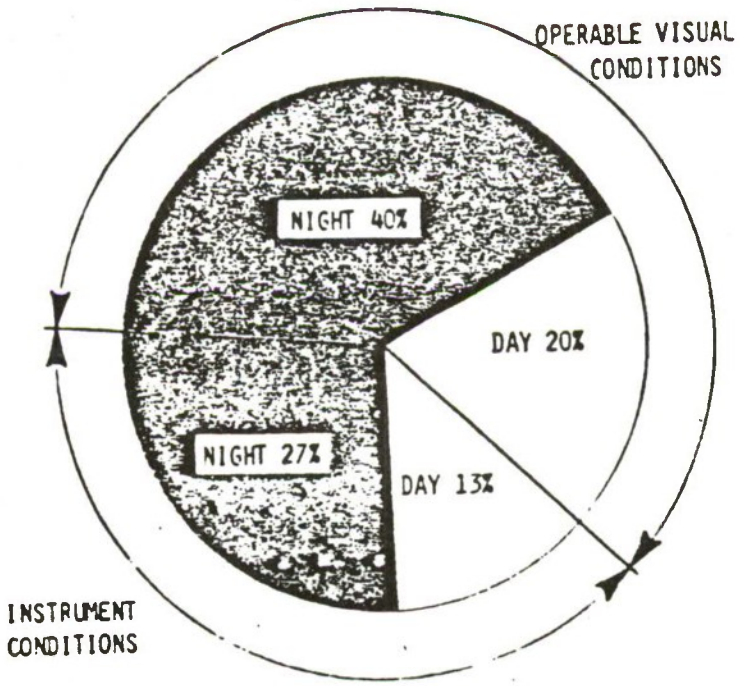
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F-15E FORWARD COCKPIT

F/A-18 HORNET COCKPIT





FLYING CONDITIONS - CENTRAL EUROPE

WINTER - TYPICAL 24 HR PERIOD

NIGHT POLE NEEDS

PILOT CONSIDERATIONS

- FATIGUE
- REACTIONS SLOWED
- PERCEPTIONS IMPAIRED
- SUBJECT TO ILLUSIONS, DISORIENTATION, DISTRACTION, & CHANNELIZED ATTENTION

AIRCRAFT CONSIDERATIONS

- BETTER ATTITUDE REFERENCES TO INCLUDE LARGE DEDICATED ATTITUDE DISPLAY HIGH IN CENTER OF INST PANEL
- CRITICAL CONTROL PARAMETERS FORMATTED FOR INSTANT UNEQUIVOCAL RECOGNITION
- BETTER COCKPIT/INST LIGHTING, LESS CPY GLARE & REFLECTIONS
- BETTER FORMATION LIGHTING, NO FALSE HORIZONS

SUGGESTED IMPROVEMENTS: PRESENT A/C

- HUD:

  INST MODE -
  - VERTEX POINTER ON FPM
  - RADICALLY CHANGE PITCH SCALE PATTERN FROM + TO - AND WITHIN NEGATIVE
  - CONSIDER COLOR CHANGE AS REDUNDANT CUE
  - LENGTHEN ALL PITCH SCALE LINES
  - PATTERNED ANALOG FORMAT FOR PARAMETERS SUCH AS ASI, ALT, VVI, AOA & G

- DEDICATED ATTITUDE INDICATOR HIGH IN CENTER OF INST PANEL
  - CONSIDER HUD CONTROL PANEL AREA FOR PROJECTED IMAGE OR FLAT PANEL DISPLAY
  - CONSIDER PVD
- IMPROVE NON-VISUAL CUES TO AIRSPEED
- IMPROVE SPOT LIGHTING
  - CONSIDER GOOSENECK LAMPS
- REDUCE GLARE & REFLECTIONS
  - CONSIDER GLARE SHIELD EXTENSIONS/BATWING SHADES
- GPWS
- RADAR ALTIMETER

SUGGESTED IMPROVEMENTS - FUTURE A/C

- HUD
  - IMPROVEMENTS FOR ATTITUDE AS BEFORE
  - DEDICATED ATTITUDE INDICATOR ON HUD CONTROL PANEL
- DEDICATED ADI/SAI BELOW HUD C/P FROM DIFFERENT INFO SOURCE
- OPTIMIZE MIXTURE OF SENSORY INPUTS: INTEGRATED ANALOG/PATTERN FORMATS: AMBIENT MODE, HEARING AND PROPRIOCEPTION
- CONSIDER MISSION DIVERSITY; E.G., BASIC INST FLYING, NIGHT WX FM, ENHANCED NIGHT ROLE

AIRCRAFT ATTITUDE WORKSHOP RECOMMENDATIONS

- WARNINGS & ALERTS TO ALTITUDE
  - DATUM PLANE TONE-SELECTABLE
  - GPWS
  - RA
- ATTITUDE DISPLAY
  - UNMISTAKABLE, JUST BELOW HUD, BIG, DEDICATED
  - SAI - RELIABLE, BIG, HEAD DOWN
- HUD IMPROVEMENTS
  - FPM - VERTEX POINTER
  - PITCH SCALES - PATTERN, COLOR DIFFERENCES (+) TO (-)
- NON-FOCAL MODE SENSORY CUES
  - AMBIENT MODE DISPLAYS - PATTERN/ANALOG FMAT - ASI, ALT
  - AUDITORY/TACTILE CUES - AIRSPEED
  - AUDITORY CALLOUT OF CERTAIN INFO - ASI, ALT, FUEL STATE
- NOISE-CANCELLING HEADSETS

AIRCRAFT ATTITUDE WORKSHOP RECOMMENDATIONS (CONT'D)

- NIGHT ROLE
  - GLARE & REFLECTIONS
  - COCKPIT LIGHTING
  - FM LIGHTING
  - FALSE HORIZONS
- G-LIMITER BY-PASS
- AUTO-RECOVERY
  - PANIC BUTTON
  - CRASH RESISTANT FLIGHT CONTROL SYSTEM
- TRAINING
  - ATTENTION
  - VISION
  - HUD USE
  - BASIC INSTRUMENTS
  - G-TOLERANCE

SUMMARY

TO	NEED
MAINTAIN/REGAIN ATTITUDE AWARENESS	ATTITUDE DISPLAY PROMINENT, BIG, DEDICATED
ALERT TO ALTITUDE	AUDIO TONES/GPWS
PREVENT CWG	AUTO-RECOVERY SYSTEM

ATTACHMENT Z

MEETING 15

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5-7 November 1985/San Diego, California

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